POWER

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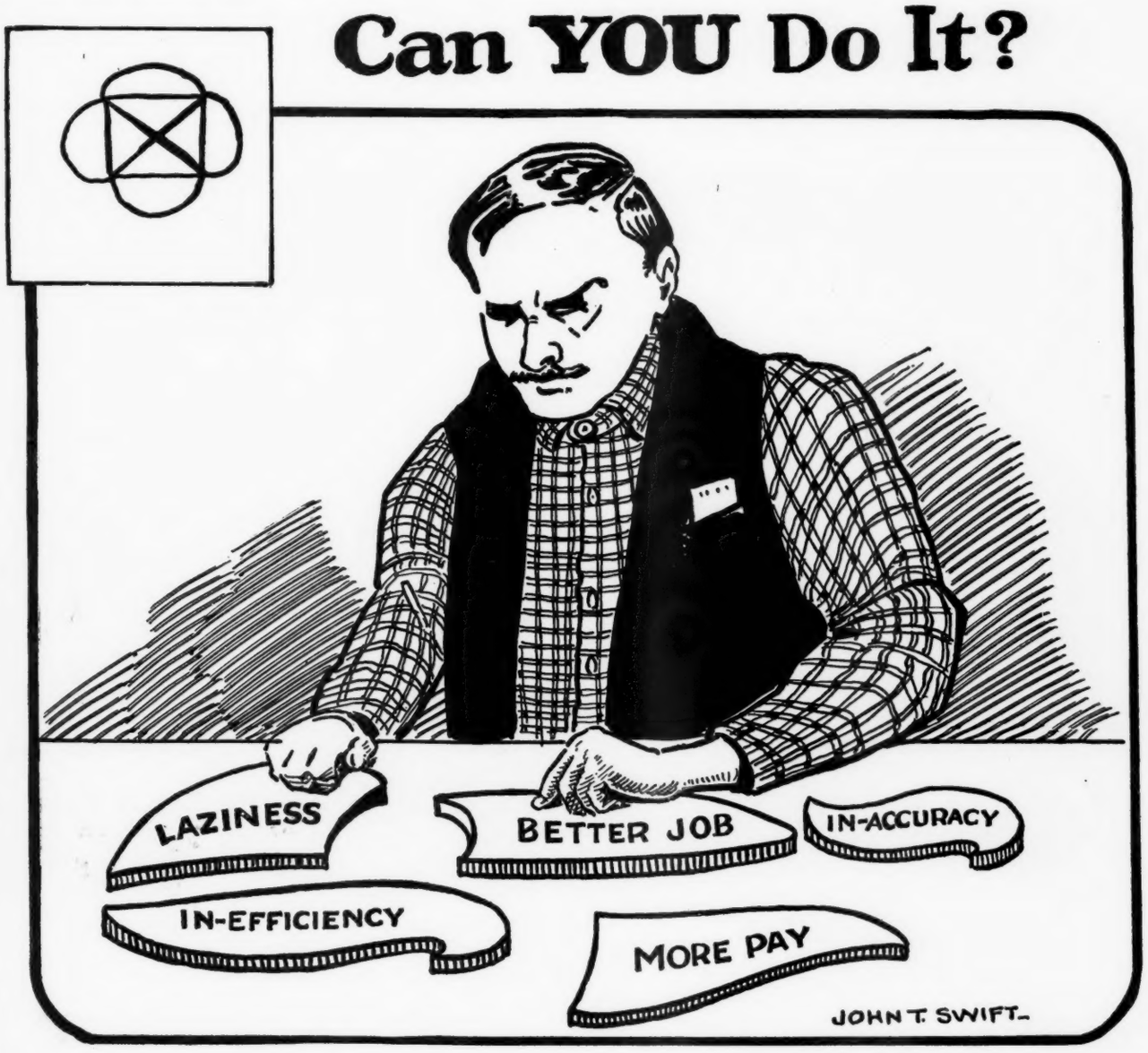
Can YOU Do It?



The Jig-Saw Puzzle

Can you make the figure in the upper left-hand corner without taking your pencil from the paper, or without re-tracing a line?

Neither can you make a scheme of success with the combination on the table. Whittle off the "ins" in in-accuracy and in-efficiency.

New Turbine Plant of the Hudson Motor Car Co.

Turbo-Generator Installation Added to Existing Boiler and Air-Compressor Plant—Formerly, Electrical Energy Was Purchased and Live Steam Used for Heating and Process Work—Turbines of Condensing and Non-Condensing Types Installed with Flexible Arrangement To Supply Varying Quantities of Exhaust Steam

UP to 1918 the Hudson Motor Car Co., of Detroit, had a power plant consisting of four 4,000-sq.ft. water-tube boilers equipped with underfeed stokers supplying steam to two large air compressors and additional live steam for heating and process work. This steam was conveyed to the various buildings at 150 lb. boiler pressure and reduced to 10 lb. pressure before being introduced into the heating system. All current for power and light was purchased. During the summer of 1919 the company built the Essex Plant, two blocks distant from the power house, consisting of four main buildings of one-story steel, mill construction, containing a total of 360,000 sq.ft. of floor area. Also, a six-story building containing 288,000 sq.ft. of floor area was added to the main Hudson group, which, with the Essex addition, increased the total floor space to 1,525,000 sq.ft. and practically doubled the heating and electric requirements of the company.

With such an enlarged demand for electrical energy and for steam, an addition to the power plant was needed. The public-utility company supplying the current was heavily overloaded, and there was a possibility of having the supply of purchased current curtailed. It was decided by the company to generate its own current and at the same time revamp the heating and process systems so that the vast quantity of exhaust steam from the air compressor and power services could be utilized to advantage. More radiation was installed in the drying and japanning ovens so that exhaust steam could be used instead of live steam, this being particularly important during the warmer months when no steam would be required for heating.

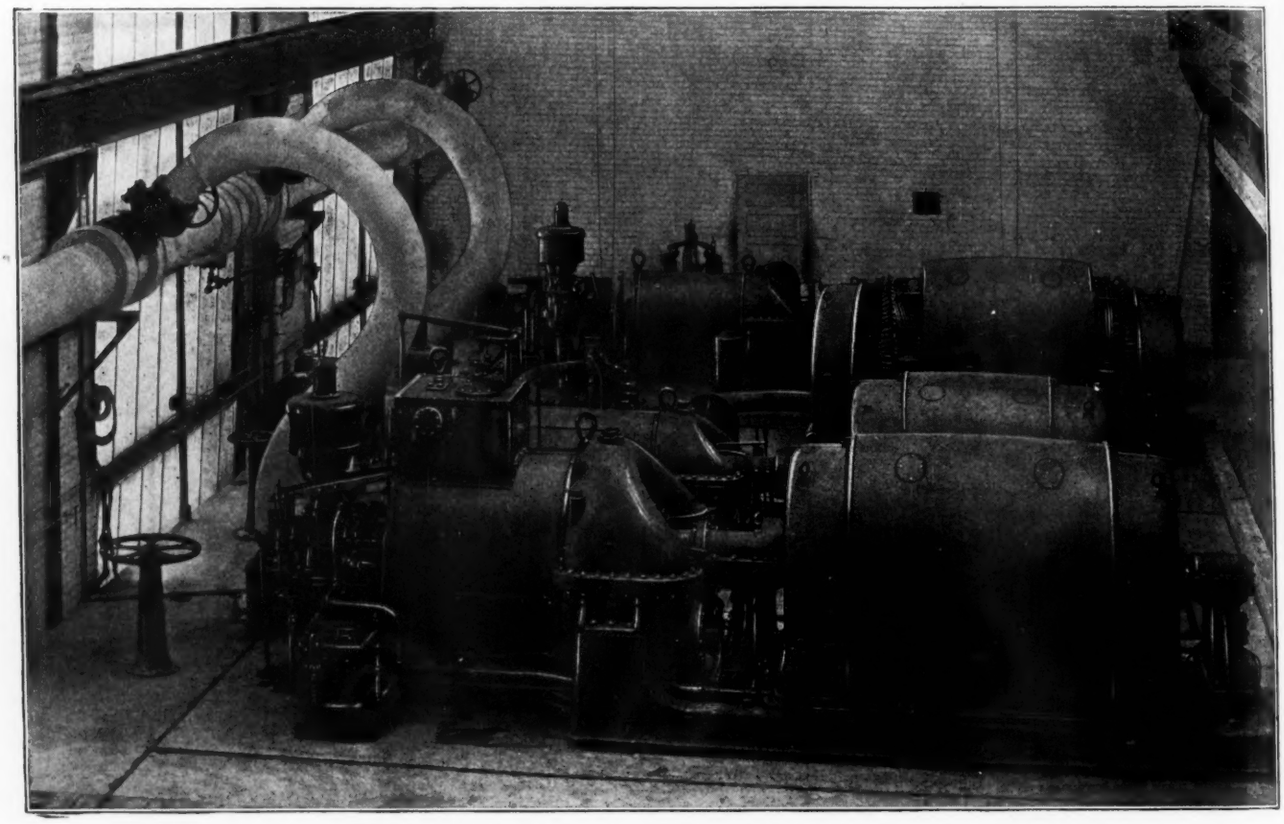


FIG. 1. NEW TURBO-GENERATORS INSTALLED AT THE HUDSON MOTOR CAR COMPANY'S PLANT

It was decided to install three non-condensing turbo-generators discharging into a common exhaust main with the air compressors and two mixed-pressure condensing units which could draw upon the exhaust steam main, use live steam entirely, or a combination of both, depending upon conditions. In the exhaust main a pressure of 10 lb. is to be maintained. Each turbine is equipped with an atmospheric release so that if the

demand for exhaust steam decreases and the pressure tends to rise, the steam will discharge to the atmosphere. If the pressure in the main drops, there is provision to draw upon the live-steam supply from the boilers through a reducing valve. It is the intention, however, to use the turbines in such a way that the supply and demand for exhaust steam will practically balance, the condensing units being used probably to a greater extent during the warmer months when the heating system is shut down. Highly economical operation is anticipated, and it is expected that a great saving will be made over the old method if a practical exhaust steam balance can be maintained.

The final plan is to install one 1,250-kw. and two 1,800-kw. non-condensing turbines and two mixed-pressure condensing units, one rated at 2,000 kw. and the other at 1,800 kw. Three machines are now installed, two of them non-condensing, rated at 1,250 kw. and 1,800 kw., and also a 2,000-kw. condensing unit.

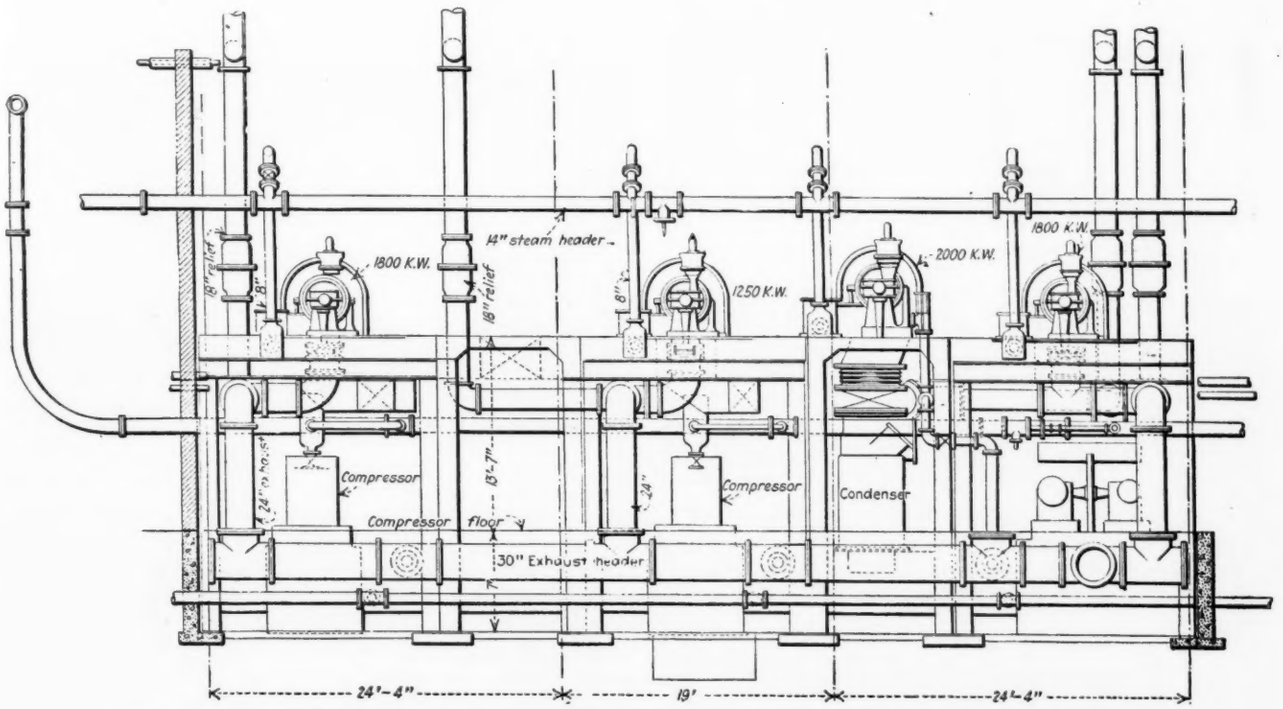


FIG. 2. ELEVATION THROUGH TURBINE AND COMPRESSOR ROOM, SHOWING PRESENT UNITS AND AT THE RIGHT ONE OF THE FUTURE UNITS

As the floor area in the power plant was limited and the ceiling high, it was decided to erect a superstructure over the air compressors to carry the generating units, Fig. 2. On either side of the compressors excavations were made to the footing under the compressor-room floor and reinforced-concrete walls carried up to support the turbine-room floor. The foundation walls,

EQUIPMENT IN ADDITION TO POWER HOUSE, HUDSON MOTOR CAR CO.

No.	Equipment	Type	Size	Use	Operating Conditions	Maker
2	Boilers	Water-tube	6,000 sq.ft.	Generation of steam	150 lb. steam, forced draft	Babcock & Wilcox Co.
2	Stokers	Jones		Coal feed	Fed from overhead coal hoppers	Underfeed Stoker Co.
2	Coal-weighing machines	Automatic	300-lb.	Weighing coal for stokers		Richardson Scale Co.
2	Blowers	No. 6	32,000 cu.ft. min.	Forced draft for boilers	Motor driven, 840 r.p.m.	Bailey Mfg. Co.
1	Turbo-generator	Non-condensing	1,800-kw.	Generation for power and lighting	3,600 r.p.m., 4,600-volt, 3-phase, 60-cycle	Westinghouse Elec. & Mfg. Co.
1	Turbo-generator	Non-condensing	1,250 kw.	Generation for power and lighting	3,600 r.p.m., 4,600-volt	Westinghouse Elec. & Mfg. Co.
1	Turbo-generator	Condensing	2,000 kw.	Generation for power and lighting	3,600 r.p.m., 4,600-volt, 3-phase, 60-cycle	Westinghouse Elec. & Mfg. Co.
1	Air compressor	Corliss tandem-compound	18 and 30-16½x26x30	General Comp. air supply	150 lb. steam, 100 deg. superheat, 100 lb. air	Sullivan Machinery Co.
1	Air compressor	Corliss tandem compound	20 and 34-18 and 30x30	General Comp. air supply	150 lb. steam, 100 deg. superheat, 100 lb. air	Sullivan Machinery Co.
1	Air compressor	Class C.C.P.	27x16x16x28x22	General Comp. air supply	150 lb. steam, 100 deg. superheat, 100 lb. air	Bury Compressor Co.
1	Air-washing machine	Spray-jet	60,000 cu.ft. min.	Wash air for compressors and generators	Spiral mist nozzles fed from circulating pump	Atmospheric Conditioning Corp.
1	Surface condenser	Rectangular	57,000 lb. of exhaust per hour	Condensation on 2,000 kw. turbine	28-in. vacuum, 8,000 g.p.m. cooling water, 80 deg.	Wheeler Condenser & Eng. Co.
1	Cooling tower	Forced-draft	8,000 cu.ft. min.	Cooling water for condenser	Cools from 96 to 80 deg. F.	Wheeler Condenser & Eng. Co.
2	Cranes	Locomotive	Bucket ¾ and ¾ yd.	Transferring Coal	As required	Osgood Co.
1	Hoist	Brown-Hoist	1-ton bucket	Coal and Cinders	As required	Brown Hoisting Mch. Co.

Fig. 3, are isolated from the main floor by a 2-in. space. They were made 15 in. thick, and the height from the footing to the bedplate of the turbine is about 19 ft. The supporting members for two of the generating units consist of 14-in. girder beams extending across the foundation walls. For the 2,000-kw. machine the support consists of reinforced-concrete beam and slab

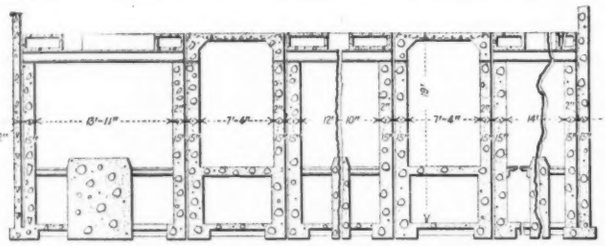


FIG. 3. SECTION THROUGH TURBINE FOUNDATION

construction. The machines already in operation give no indication of troublesome vibration.

Three-phase 60-cycle current is generated at 4,600 volts. The current is transmitted directly to the various buildings, where some of it is used at generator voltage and the remainder transformed down to 220 volts, three-phase, for motor service and 110 volts, single-phase, for lighting. Fig. 6 shows a side elevation of one non-condensing unit.

One surface condenser containing 9,320 sq.ft. of surface will serve the two condensing turbines. It is to be provided with a reciprocating condensate pump dis-

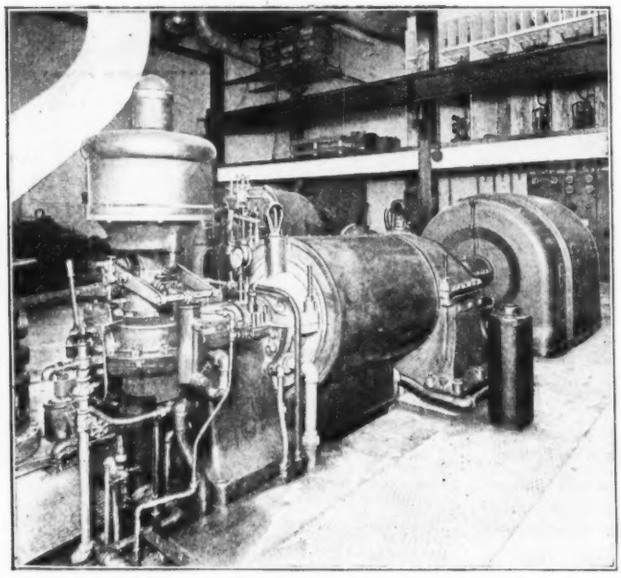


FIG. 4. THE 1,250-KW. TURBO-GENERATOR UNIT OPERATING NON-CONDENSING

charging through a radojet air pump into the boiler-feed system. The boiler-feed system consists of two receiving surge tanks, 6 ft. in diameter and 21 ft. 2 in. long, placed below the boiler-room floor level. These tanks receive the returns from the heating system, traps, condensate pump and radojet air pump. From these tanks the water is pumped into a large surge tank located just below the roof of the building, thence to the open-type feed-water heater, which is located about 12 ft. below the upper surge tank. The lower receiving tanks, the surge tank and the heater all operate under a 10-lb. steam pressure taken from the exhaust main. As the tanks are two-thirds full of water and the rest is steam, the water is in direct contact with the steam and is therefore partly heated when it enters the feed-water heater, giving a final temperature of 235 deg. F.

Condenser cooling water is circulated by a motor-driven centrifugal pump. The water used for this

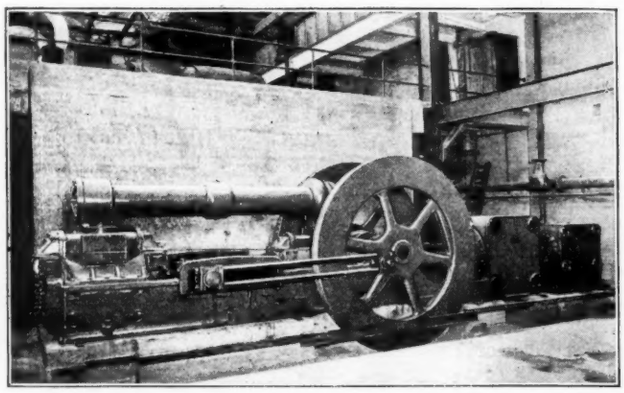


FIG. 5. NEW COMPOUND AIR COMPRESSOR

purpose is conserved by a forced-draft cooling tower located on top of a building across the street, this arrangement being necessary owing to a coal crane traveling the full length of the power house to pick up coal from storage. From the cooling-tower plant the water flows by gravity through a 16-in. line under the street to the condensers. A tap from this line supplies water for cooling the turbine bearings, air-compressor

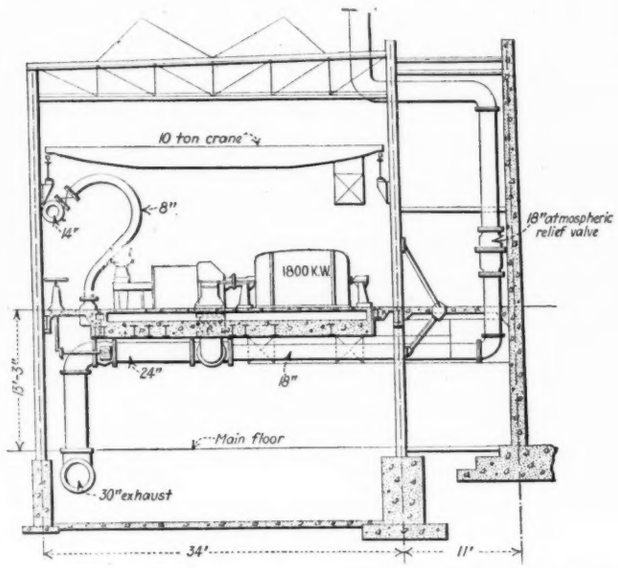


FIG. 6. SIDE ELEVATION OF ONE NON-CONDENSING UNIT

cylinders, intercoolers, etc., and all of it is again collected in a pit underneath the compressor-room floor, from which it is forced back to the top of the cooling tower by the centrifugal pump previously mentioned. Any makeup water required comes from the city mains, being admitted to the pit under float control. It is the intention of the city to extend a large storm sewer past the power house, and it is the plan to use water from this source for condensing purposes.

Air for the compressors and for cooling the generators will be taken in through a penthouse on the roof of the power house. It will pass through air-washing equipment to be located on a balcony off the turbine floor, and from there flow on to the air compressors, and through the generators out into the turbine room. Three Corliss tandem-compound air compressors, one of which is shown in Fig. 5, are now in service, and it is the plan to install a fourth unit.

With the heating and power demands so greatly increased, it was necessary to add to the boiler room. The original plant consisted of four 4,000-sq.ft. water-tube boilers. Later, two 6,000-sq.ft. water-tube boilers equipped with underfeed stokers were added, and as a part of the new installation two more 6,000-sq.ft. boilers (Fig. 7) were installed in a new boiler house. As no more space was available in the old boiler room, it was necessary to build this second boiler house at the opposite end of the compressor and turbine room. This addition was made at right angles to the older portion of the building, so that, as it is extended along the property line for future additions, it will form an L-shaped structure. All boilers are now being equipped with superheaters giving 150 deg. of superheat at 150 lb. pressure.

At present, coal for boiler house No. 1 is stored in the unoccupied space back of the power house shown in

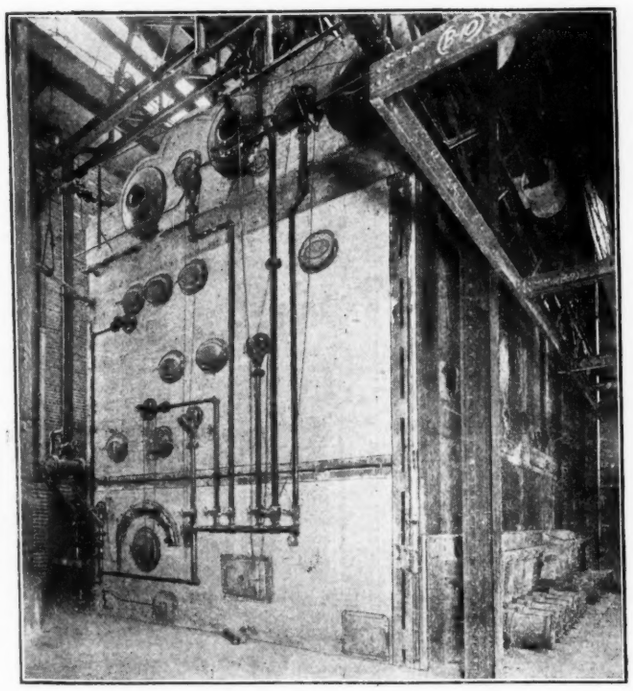


FIG. 7. TWO NEW 6,000-SQ.FT. BOILERS

Fig. 8. From the railway cars it is dumped into a coal pit and by means of an electrically operated locomotive crane with a 1-ton bucket traveling the full length of the top of the power house, is transferred to yard storage or to a crusher traveling on the same track as the crane. This crusher discharges directly into an overhead bunker in the boiler room which delivers through chutes to the stokers. The arrangement is simple and will be used for the present, the main disadvantage being the freezing of coal in the open bunkers in the winter time and the amount of work required in reclaiming coal from the far parts of the yard. This is being done by two locomotive cranes of the caterpillar type and two portable conveyors.

Coal to the two new boilers will be taken care of by extending the present overhead track to the west end of the new bunkers, which is at right angles to the track. A short drag conveyor will distribute coal to

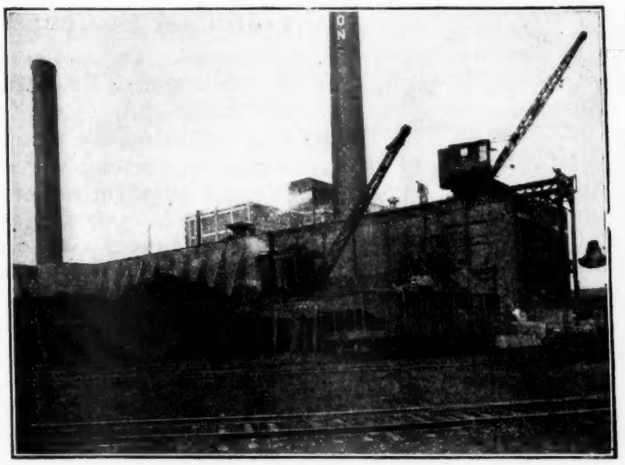


FIG. 8. EXTERIOR OF POWER PLANT, SHOWING COAL-HANDLING EQUIPMENT

the bunkers and will also serve as a second medium for supplying coal to the roof of the power house. A bucket elevator transfers the coal from a crusher on the ground to the drag conveyor. The coal from storage is at present delivered to a bin over the crusher by one of the caterpillar cranes.

Eventually, it is the intention to erect a traveling bridge crane with the center of rotation at the corner of the L and the outer end projecting to the railroad track and revolving along it, the bridge being supported on a single rail placed on the retaining wall between the coal yard and the track. With several unloading pits this system would give the maximum speed in unloading cars of coal and make it possible to place the coal at any point in the yard with one handling. In reclaiming from the yard, the coal would be dropped into a bin over the crusher located at the pivot of the traveling bridge. It would have to be elevated by a bucket elevator to belt conveyors, one leading to each line of bunkers.

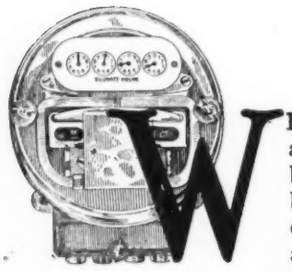
At present, ashes from the six boilers in the older section of the plant are dumped from the ash hoppers under the stokers into industrial cars, these cars in turn being emptied into a pit at the end of the boiler room from which the ashes are transferred to railway cars by the coal crane on top of the power house. Owing to the fact that headroom in the ash tunnel is not of sufficient depth to allow for a car big enough to take the ashes from the 6,000-sq.ft. boilers in boiler room No. 1, a drag conveyor is to be installed to handle these ashes. The ash tunnel to the new extension is deeper and is to be equipped with a track and ash car, the car dumping ashes into a skip hoist delivering to an overhead bunker.

Individual weighing scales and flow meters are installed for each boiler, also meters in boiler-feed lines and steam-flow meters in all main supply lines. Each turbine is equipped with a flow meter and the output of the generator is recorded.

Switchboard-Meter Connections—Simple Alternating-Current Circuits

Connections With and Without Instrument Transformers on Single-Phase Two- and Three-Wire Circuits—Multi-Circuit Ammeter and Voltmeter Switches for Two-Phase Circuits

By E. A. REINMAN



WHEN checking the wiring of an alternating-current switchboard panel, no attention need be paid to the polarity of either ammeter or voltmeter, as the instrument gives a positive deflection regardless of the direction of current flow. The most important point to watch is that the voltmeter has the external resistor properly connected in series if one is required.

When wattmeters or watt-hour meters are employed, however, attention must be paid to the direction of power flow. The terminals are sometimes marked ± and ∓, indicating that when one is positive the other is negative and vice versa. For instance, Fig. 1 shows the connections for an alternating-current wattmeter with current and potential windings. The two left-hand terminals are ± and the two right-hand are ∓.

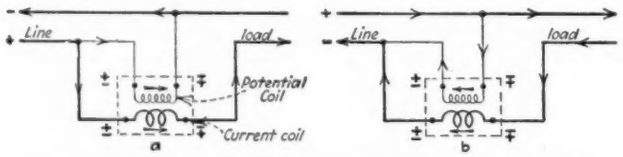


FIG. 1. SINGLE-PHASE WATTMETER CONNECTIONS, SHOWING INSTANTANEOUS CURRENT FLOW

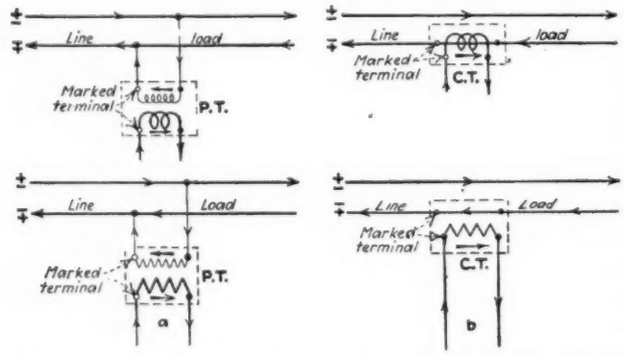


FIG. 2. (a) TWO METHODS OF REPRESENTING POTENTIAL TRANSFORMERS; (b) TWO METHODS OF REPRESENTING CURRENT TRANSFORMERS

This means that when the left current terminal is + (in other words when the current is entering it) the left potential terminal must be +, and the instantaneous direction of current flow is shown by the arrowheads in Fig. 1*a*. When the supply reverses, the left current terminal and the left potential terminal both become — and the direction of current flow is as shown in Fig. 1*b*. The reaction between two positive or between two negative currents results in a positive deflection or registration.

Alternating-current switchboard instruments are generally used with voltage or potential transformers and current or series transformers. As before, in the case of voltmeters or ammeters alone the polarity has no effect; but when used with a wattmeter or watt-hour meter, the polarity must be taken into consideration.

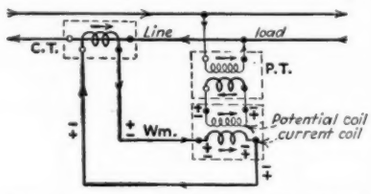


FIG. 3. WATTMETER CONNECTIONS, USING CURRENT AND POTENTIAL TRANSFORMERS

Instrument transformers are usually marked for polarity by painting one lead of the primary and one lead of the secondary with red or white paint. This means that when current is entering the marked primary lead at any instant, it is leaving the marked secondary lead, and vice versa. In the diagram of connections the voltage transformer is usually represented as shown in Fig. 2*a*, where the small arrows show the instantaneous direction of current flow. The current transformer is represented as in Fig. 2*b*. It will be noted from the directions of current flow that the circuit can be traced out exactly as if the transformer were omitted. For instance, consider the wattmeter connected to current and potential transformers as in Fig. 3, where the directions of current flow are shown at a particular instant. Place the finger over either transformer and the currents may be traced out exactly as before. In actual practice the leads of the transformer would be marked as shown in Fig. 4 where the white marking on a primary and a secondary lead is plainly shown.

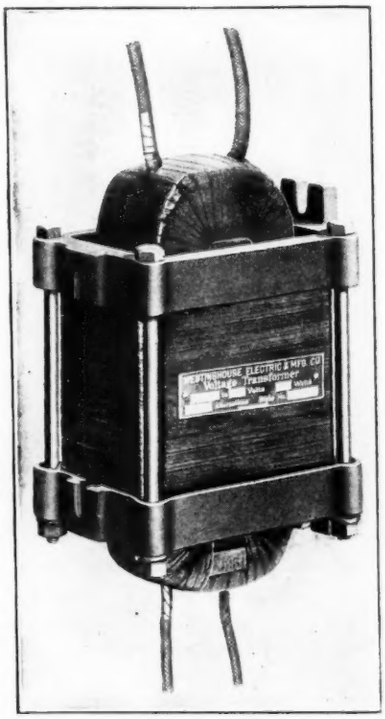


FIG. 4. TYPE OF POTENTIAL INSTRUMENT TRANSFORMERS, SHOWING POLARITY MARKING ON LEADS

The single-phase three-wire system may be considered as two simple circuits with one wire common to both. Ammeters may be connected in either outside wire to measure the current in that wire; an ammeter in the neutral or common wire measures the unbalanced current or the difference between the currents in the two outside wires; and a three-wire instrument measures

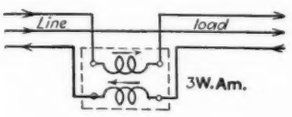


FIG. 5. CONNECTIONS FOR THREE-WIRE AMMETER

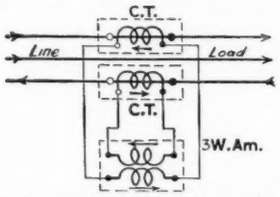


FIG. 6. THREE-WIRE AMMETER WITH TWO CURRENT TRANSFORMERS

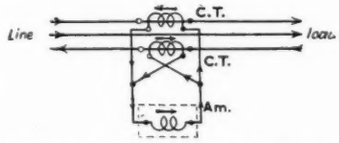


FIG. 7. SINGLE-COIL AMMETER WITH TWO CURRENT TRANSFORMERS

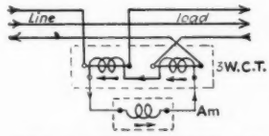


FIG. 8. SINGLE-COIL AMMETER WITH THREE-WIRE TRANSFORMERS

the sum of the currents in the outside wires. Fig. 5 shows the connections for a three-wire ammeter.

When current transformers are used with this instrument it is necessary to observe the polarity of the coils, for if one coil is reversed the instrument will read the difference instead of the sum of the currents. Fig. 6 shows the connections to produce the correct polarity, while Fig. 9*a* shows the connections with one winding reversed, causing the coils to oppose each other. It will be noted that the direction of current flow need not be known, as the polarity depends entirely on the connection and not on the flow. In connecting up three-wire meters the coils may be crossed as shown in Fig. 9*b*.

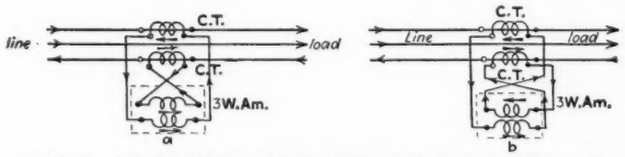


FIG. 9. INCORRECT CONNECTIONS FOR THREE-WIRE AMMETERS

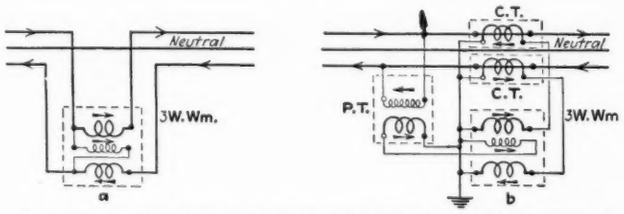


FIG. 10. CONNECTIONS FOR THREE-WIRE WATTMETER WITH AND WITHOUT INSTRUMENT TRANSFORMERS

While this results in correct polarity and deflection when the currents are equal, there is a serious error when the system is unbalanced.

Instead of using a meter with two windings and two transformers, a single-winding meter and a three-wire transformer are often used with connections as in Fig. 8. Or if it is preferred, two transformers may be used with their primaries in each line and their secondaries connected in parallel, as in Fig. 7.

Voltmeters may be connected to a three-wire system to indicate either the voltage between outside wires, the voltage from either outside wire to neutral, or the difference of the voltages between outside wires and neutral. For simple voltmeters no attention need be paid to polarity, while for the last case special differential voltmeters must be employed and the connections made to obtain correct polarity. There are several schemes for this. One uses two voltmeter elements acting on one shaft and pointer; another uses two differential windings on the voltmeter, and the third employs a bridge arrangement in which the unbalanced voltage is led to a moving coil, which reacts on a field produced by a separate potential winding. This has the effect of giving large open-scale divisions for a small unbalancing of voltage.

Three-wire wattmeters and watt-hour meters are extensively employed as they measure the total watts regardless of unbalancing of the load. In the self-contained watt-hour meters the potential coil is usually connected across the outside wires, as it was found that meters having the potential coil connected between one wire and neutral were easy to defraud. The polarity must now be taken into consideration and the transformers wired to give the same polarity on the instrument. The connections for a three-wire meter for direct connection to the line are shown in Fig. 10*a*; those of a transformer-type meter, in Fig. 10*b*. In the latter case there is a common point between both current transformers and the voltage transformer, and this point as well as the meter case should be well grounded. As will be seen from the direction of the arrows, the direction of current in the coils is the same as when transformers are not used. In both cases the direction of power flow must be known. From a study of Fig. 10 it will be clear that there are a great many chances for error, and it is only by carefully tagging or coloring the wires and making a diagram that the meter can be expected to register in the correct direction when the current is turned on.

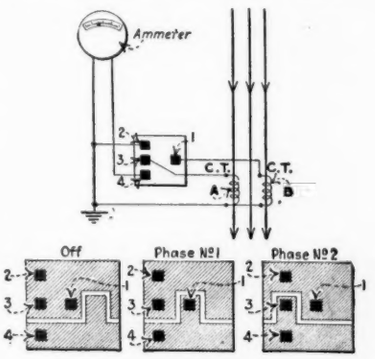


FIG. 11. MULTICIRCUIT AMMETER SWITCH AND CONNECTIONS

Two-phase circuits may be either three-wire or four-wire, but as far as tracing out the connections to determine correct polarity, they may be treated as either a three-wire single-phase or two separate two-wire single-phase circuits. Ammeters and voltmeters, as before, do not require a polarity determination for their correct operation. A three-wire ammeter cannot be used in a two-phase circuit, and if the current in each phase must be determined, it is necessary to employ either two ammeters or an ammeter switch. When changing an ammeter from one circuit to another, it is important that the circuit remain closed at all times. If, on the other hand, the ammeter is connected through a current transformer, it is equally important that the secondary of the transformer remain closed at all times, for if it be opened while current flows through the primary, its phase-angle may be permanently changed. For these

reasons the ammeter switch must do four things in changing the ammeter from one phase to the other, whether instrument transformers be used or not: First, it must short-circuit or bypass the ammeter; second, it must disconnect the ammeter from the first phase; third, it must connect the ammeter to the other phase or transformer, and fourth, it must open the bypass to allow current to flow through the windings of the instrument.

The connections of a type of ammeter switch for use with transformers are shown in Fig. 11. The switch itself consists of a drum with copper segments on it and with metal fingers making contact on this drum. As the drum is turned, it assumes the position shown in the development of the drum segments in Fig. 11. In the off position, fingers 1, 2 and 3 are short-circuited, thus closing both transformer secondaries and opening the ammeter circuit. As the drum is rotated by means of a handle or knob, to the position 1, fingers 2 and 3 are connected as are fingers 1 and 4. This still short-circuits transformer *A*, but connects the ammeter to transformer *B*. As the switch is turned to position 2, it short-circuits transformer *B* and connects the ammeter to transformer *A*. In tracing out the connections, care must be taken to bring the common wire to finger 2 and one ammeter lead to finger 4. It makes no difference which transformer leads and which ammeter leads come together to form the neutral, because neither polarity nor direction of power flow can change the ammeter reading.

By means of special voltmeter switches one voltmeter may be used to read the voltage on either phase of any number of generators or feeder circuits. The voltmeter is usually placed on a swinging bracket at the end of a switchboard so that it may be read by the operator as he passes from panel to panel. There are two wires *A* and *A'*, called the voltmeter bus, which run the length

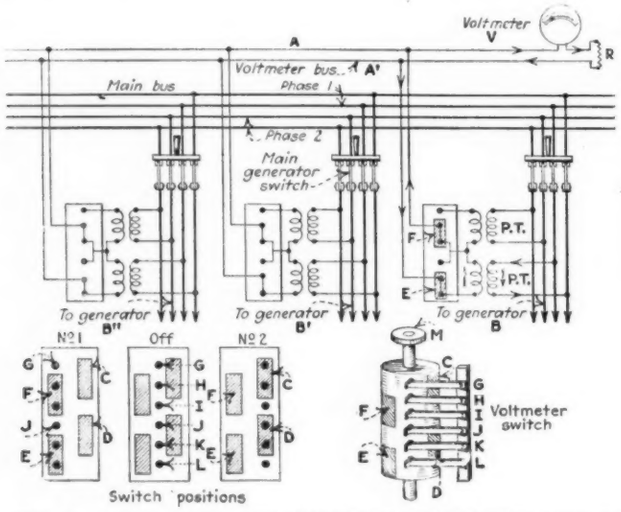


FIG. 12. DRUM-TYPE MULTICIRCUIT VOLTMETER SWITCH AND CONNECTIONS FOR THREE TWO-PHASE CIRCUITS

of the board and connect to the voltmeter *V* and its resistor R, Fig. 12.

Two types of voltmeter switches are illustrated in Figs. 12 and 13. Fig. 12 shows three two-phase generator circuits feeding onto a main bus, each generator panel being equipped with a revolving type of voltmeter switch, *B*, *B'* and *B''*. These switches have a revolving drum with metal segments *C*, *D*, *E* and *F*, which make contact with stationary fingers *G*, *H*, *I*, *J*, *K* and *L*, as the drum is turned by means of the handle *M*. This handle (or key as it is sometimes called) is removable only when the drum is in the off position, and as only one handle is supplied for each switchboard, it eliminates any chance of turning on two switches at once. The figures below the diagram of connections show the development of the drum in three positions, on open cir-

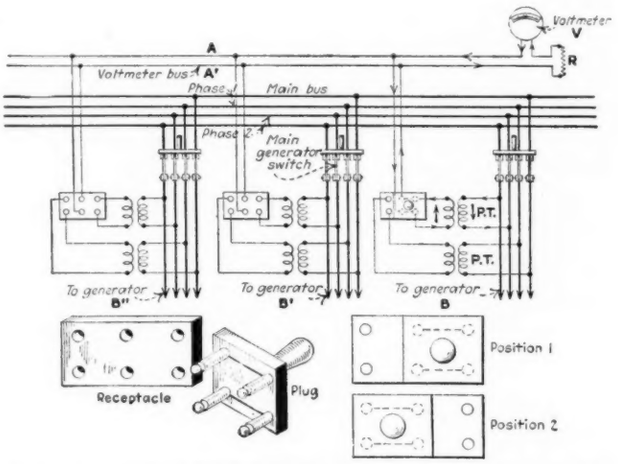


FIG. 13. PLUG-AND-RECEPTACLE MULTICIRCUIT VOLTMETER SWITCH AND CONNECTIONS FOR THREE TWO-PHASE CIRCUITS

cuit and for measuring voltage on phase 1 and phase 2. In the "off" position the contact fingers *G* to *L* are all on open circuit. As the switch is turned to position 1, segment *F* connects contacts *H* and *I* while segment *E* connects contacts *K* and *L*. As shown in switch *B*, this results in connecting voltmeter *V* to phase 1 with current as shown by the arrowheads.

Rotating the switch to position 2 results in segment *C* and *D* connecting *G* to *H* and *J* to *K*, thus connecting the voltmeter to phase 2. In a similar manner, switches *B'* and *B''* may be turned to read the voltage on either phase of the generator to which these are connected.

Fig. 13 illustrates three two-phase generator circuits feeding onto a main bus, each generator panel being equipped with plug-and-receptacle type voltmeter switches. With the connections shown, it is possible to read the voltage on the two different phases in each circuit. A sketch of the receptacle and the plug shows the two positions for voltage measurements in the two phases. There being only one plug, it is not possible to connect the voltmeter to more than one phase at once.

Among many dangerous practices are two which, although not related, seem to exist together in power-station work. One is the synchronizing of two alternators by guess; that is, by watching the effect of the current alternation on an incandescent lamp. The other is the "cutting in" of a boiler on a header that is being supplied by other boilers. In the first case a very simple, inexpensive and absolutely reliable synchronizing indicator is procurable, and in the second a still cheaper and simpler device in the form of a non-return valve, which will not only prevent the boiler from being cut into the line too soon, but will also protect the entire system in the event of a tube bursting in one boiler. Non-return valves are a necessity, but education as to their being such is an inordinately slow process.—*Warren Hilleary.*

Setting Ammonia Expansion Valves

By J. C. MORAN

SETTING the expansion valve of an ammonia refrigerating plant that has only a single expansion valve is a simple job. Generally, every refrigerating engineer has some settled idea or notion about when the machine is running just right, and all he has to do when there is only one expansion valve is to keep on adjusting it until the machine works right. However, there is considerable difference of ideas about when a machine is working right. Some insist on carrying the frost line back so far that the cylinder of the machine gets frosted and the water freezes in the water jacket at times. Others only carry the frost line to within a few feet of the suction header of the machine.

Still others gage their ideas of the work the machine is doing by feeling of the discharge line, handling the expansion valves in such a way that discharge is so hot that the hand can be barely held on it for a short time. Others gage their setting of the expansion valves and the operating of the machine by the suction pressure. Some judge the operation of the machine by the temperature of the piston rod, as determined by feeling of it at regular intervals with the bare hand.

All these methods of judging the operation of the machine have their advantages under certain circumstances, and all will be taken into consideration by the operator who knows his business. The whole secret of efficient ice-machine operation can be stated in a few words: Keep the suction pressure as high as possible to do the work in the lowest temperature service and return the suction gas to the machine in a saturated but not wet condition—a few degrees of superheat will not hurt. If the gas comes to the machine a few degrees superheated, there is no trouble with liquid entering the machine and reducing the capacity as well as increasing the power requirements per ton of refrigeration.

Use of Thermometers

The latest and scientific method of judging the operation of an ice machine is to use thermometers in both the suction and discharge lines and, in connection with the suction gage, to adjust the operation of the machine according to the indications of these. For every suction pressure there is a corresponding temperature, if the gas returns to the machine in a saturated condition. These values are shown in the ammonia tables in *Power*, Jan. 18, 1921, issue. If the gas returns more or less superheated, the temperature will of course be higher than the temperature corresponding to the suction pressure.

Gages as a general rule never remain accurate for long periods, and even thermometers have been known to get out of order. Thermometers, however, do not get out of order nearly as often as a pressure gage, and as a consequence it can be generally assumed that the gage is to blame if the two do not correspond.

To check the two, open up on the expansion valves until the discharge line gets cool enough so that the hand can be comfortably held on it, when under the average operating conditions there will be a small amount of liquid carried along with the suction gas into the machine and the returning suction gas will be fully saturated. Note the temperature of the suction gas and then from the ammonia tables find the pressure that corresponds to this temperature. If the gage registers this pressure, it is probably correct to within a fraction of a pound. If there is a difference, it will be the same over the general operating range of the suction pressure, and after the difference is once noted it can be added to or subtracted from the gage reading to get the correct reading for all pressures over the entire range, which will generally be not more than five or ten pounds.

Determining Correct Compressor Temperatures

If the system is not provided with thermometers in the discharge and suction lines of the machines, one will have to judge the operation of the machines by the feeling of the different parts by hand, the suction pressure, and the frost line on the machine. As a general rule I prefer to carry the frost line back to the suction valves on the machine, keeping these frosted, while the discharge remains hot.

Under no circumstances should the machine be run cold enough to allow the water to leave the jacket colder than it enters. I have seen any number of plants run in this way, year in and year out, but the owners paid for it in increased coal or power bills. As a general rule for the beginner to follow, I would advise him to carry the frost line back to the suction valves, or nearly so, keeping the discharge line warm and the suction pressure as high as possible, and still leaving enough temperature difference between the ammonia and the room in the lowest temperature rooms to keep the temperature at the desired point. What this pressure will be will depend on the lowest temperature carried on any room in the system and the amount and cleanliness of the pipes. Even under the most favorable conditions there should be about ten degrees temperature difference between the ammonia in the coils and the temprature in the rooms, or the lowest brine temperature carried on the system in case brine is used. Sometimes where a room or a brine cooler or tank is heavily piped, it is possible to operate with a temperature difference considerably lower than this, but these cases are few and far between.

Coils with Different Temperatures

Now, as I have said before, it is a simple matter to adjust the expansion valve when there is only one valve on the system. If there are two, there is twice the trouble, and the amount of trouble that can be experienced and the number of complications that can arise increase in direct proportion to the number of expansion valves to be handled.

To illustrate this point, let us assume that there are two valves to be adjusted on the system. Let us further assume that it is a direct-expansion system and that one room is to be held at 15 deg. F. while the other should be held at about 32 deg. F. To give a temperature difference of 10 deg. betweeen the room temperature in the lowest-temperature cooler and the ammonia in the coils, the ammonia temperature must be 5 deg. F. This corresponds to a suction pressure of about 30 lb. gage; this will be the suction pressure if the system is properly operated. If the low-temperature room is insuf-

ficiently piped, the suction pressure will have to be carried lower than this in order to keep the room temperature down. The low-temperature room, however, will determine what the proper suction pressure will be.

In many plants the room temperatures are often run much higher than desired, for the simple reason that they do not adjust the expansion valves so that the whole coil is working or, if there are several coils in the room, so that all the coils are working at maximum capacity.

Many operators have the habit of opening all the expansion valves on the system about the same amount. Very often there are different sized coils in the same room, or in a number of rooms of about the same temperature, and the operator adjusts each valve to about the same amount of opening. The result is that one coil will get more liquid than it can evaporate while others will not get anywhere near enough; as a consequence only one or two coils will be working to capacity and the rest will not be doing anywhere near what they ought to do.

Fig. 1 illustrates the construction of the average expansion valve. In many respects this resembles the average boiler gage cock, and the action of the ammonia as it passes through is identically the same as that of the water that passes out from a gage cock when it is opened. As the ammonia is expanded from the higher to the lower pressure, some of it is evaporated to cool the liquid down to the lower temperature, and the mixture as it escapes from the expansion valve into the coil is a combination of liquid and gas which shoots into the coil at high velocity.

Action of Ammonia in the Coils

In addition the ammonia already in the coil is boiling the entire length of the coil and the liquid in the coil surges backward and forward somewhat in the manner of boiling water; sometimes a sudden change of temperature takes place around a coil, or the air is suddenly agitated by the opening of a door or someone

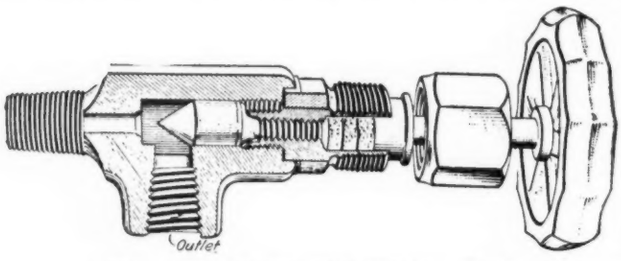


FIG. 1. STANDARD EXPANSION VALVE

working near-by, and an extra surge will take place in the coil and probably throw some of the liquid into the suction line. It will be seen that it is something of a problem to so adjust the expansion valves that every coil will get all the liquid that it will evaporate and still not throw any into the suction line.

One must always remember that for the same room temperatures a short coil will not evaporate as much liquid as a long one. A coil double the length of another in the same room will evaporate about twice the amount of liquid that the short one will. Also, a coil badly frosted will not evaporate so much liquid as one that is fairly clean. A coil of a certain length in a room where the room temperature is high will evaporate much more liquid than a coil in a room where the temperature is low. For instance, if a suction pressure of 15 lb. gage is carried, the ammonia temperature will be about zero. If one of the rooms is held at 15 deg. and another at 30 deg., there will be 15 deg. temperature difference between the room and the ammonia in the low-temperature room and 30 deg. difference in the high-temperature room. The same length of coil in the high-temperature room will evaporate about twice as much ammonia as the one in the low-temperature room, and all these things must be taken into consideration when adjusting the expansion valves.

Adjustment of Expansion Valves

For the most efficient operation one will have to size up the entire system and then adjust the expansion valves according to the coil lengths, the room temperatures and the condition of the coils. After an approximate setting has thus been determined, one should go along and experiment with each valve in turn until a point is reached where the frost line, discharge temperature, or temperatures as indicated by the thermometers in case the machine is equipped with these, approach what the operator considers the proper condition for his particular plant. This will require considerable patience and experiment on the part of the operator, but he will find after a while that for a given suction pressure and room temperature there is a certain setting for each expansion valve, and once this is determined, they will need only an occasional shaking up to keep them working properly. Of course, when the temperatures change or the suction pressure changes, some more adjustment must be made.

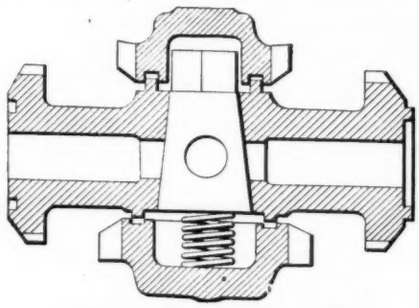


FIG. 2. EXPANSION COCK

Referring again to Fig. 1, it will be seen that the opening through the valve is quite restricted. In usual operation the valve is generally not opened much over one-quarter to one-half turn. As a consequence, the slightest amount of scale in the pipes, or dirt or other foreign matter mixed with oil, will shut off a valve in a hurry. Pieces of packing also float around in the system and help to make trouble. Regular inspections of the entire system must be made if all the coils are to be kept working at the proper capacity all the time.

To get an idea of what an expansion valve sounds like when it is working properly, place your ear against a small water valve under high pressure and catch the sort of grinding sound it makes when pretty well throttled down. An expansion valve working properly will make practically the same sound. On a short coil, however, in a cold room it can be opened only enough so that a gently hissing sound is heard. Once you get used to the various sounds made according to the adjustment required for each coil, you can quite easily tell when a coil is working properly. If, then, you find that the suction pressure begins to drop or the machine starts to get hot, you can generally detect the trouble maker by going up to each valve and placing your ear

to it. The dead one is the trouble maker. You can also tell by the frost line on the valve. At the point where the pressure changes from the high to the low, there will be a sharp frost line across the valve. The entire valve will frost over if plugged, and in this case it is simple to locate the valve that is making the trouble.

One thing that must be watched for when taking charge of a new plant is that all the expansion valves are of the regulation pattern. If the common stop valve is used, as I have found in a number of cases, the same amount of turn on the valve wheel of this will feed a much greater amount of ammonia than the regular expansion valve. The regular expansion valve has only a small hole and a needle-point valve, as will be seen from Fig. 1, and the usual stop valve has an opening several times as large as this. Furthermore, there is a difference between expansion valves of different makers, so that if there are a number of makes on the job, one will have to experiment with each make until its proper adjustment is mastered.

Fig. 2 illustrates an expansion cock, which is often used in place of the regular expansion valve. It has the advantage of quick action in case it becomes clogged and one wants to blow it clear, and there is not quite as much of a pocket for the foreign matter to accumulate as in the valve. For close adjustment, however, I prefer the valve, although for large coils where a large amount of liquid is to be fed at all times I prefer the cock. One advantage of the cock is that if you carry a handle around with you there is no possibility of anyone meddling with the valve, which is quite an advantage in a lot of places. Once the cock is set, you take the handle away with you and unless someone improvises a handle the setting will not be disturbed until you come back.

Saving by Proper Ash-Handling Equipment

BY HUBERT E. COLLINS

While the writer has no intention of claiming that the steam-ejector system is the only type of ash-handling equipment to use in every case, three cases are here cited where substantial savings were made by the installation of such systems. In each instance the equipment was of minimum size and was not operated at anywhere near its maximum capacity for any length of time. It took the equipment only a few minutes each day to handle all the ashes of the plant, and so it was not and is not now called on to work over an hour a day. The cost of renewal of parts is thus much less than where the equipment is called on to work at a maximum rate for hours each day.

That it did pay, however, to invest in an equipment that was really capable of doing much more than required to do is evidenced by what follows.

The first cost of a bucket-type conveyor would have been much more, with lower upkeep and higher operation cost, than the steam-ejector type, but with the condition of minimum operation the latter holds its upkeep and operation cost so low that this was the one to install under the conditions.

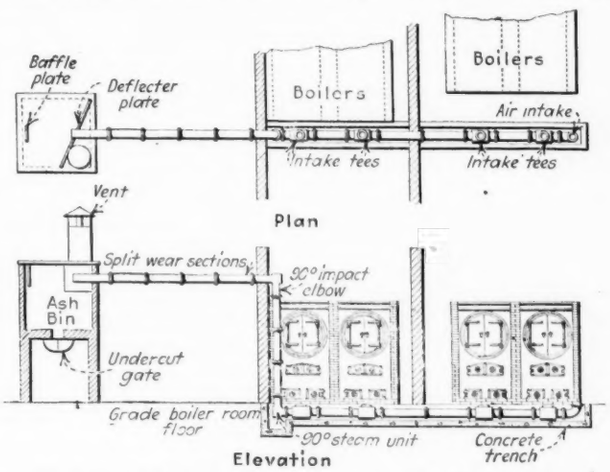
The same general type of equipment was used in each instance, although varying in detail to suit local conditions. For instance, in one case the ash-storage bin was not on a line with the ejector line in front of the boilers, but was twenty feet to one side.

In each case a series of intakes were placed under the floor, in a concrete trench in front of the boiler settings. The intakes come on a line with the center line of the boiler. This is the same whether there is one or two ashpit doors to the boiler.

The steam unit with the ejector was placed at the far end of the intake line, set with the discharge end looking up toward the discharge line.

The arrangement of the ash-storage bin was the same in each installation. The vent from this bin must be placed as shown in the illustration if the bin is away from surrounding buildings, but if close up to a factory building the vent may need to be carried off some distance from the bin.

The construction of the bin may vary. In two of the cases cited the bin was of wood, lined with concrete,



GENERAL ARRANGEMENT OF ASH-CONVEYING SYSTEM

supported on steel and in one instance of reinforced concrete. Each bin must be set high enough for wagons to pass under the discharge gate.

SAVING MADE IN ONE PLANT

At this plant the equipment was arranged as shown by the illustration, with a reinforced-concrete bin placed some distance from the boiler-house wall to make room for coal storage close by. This made the equipment item the largest of the three examples. The ashes were formerly drawn from the ashpit under the boilers to the fireroom floor, then shoveled into wheelbarrows and hauled into the yard, where they were later loaded into dump wagons and carried away. This took one man four hours a day for 300 days a year, and one man on the dump wagon for an hour each day with his team. The equipment cost was as follows: Ejector equipment, $1200; storage bin, $900; installation, $230; Total, $2,330.

The savings were: One man's pay for 300 days at 40 cents per hour is $4 \times 300 \times 40c. = \$480$; one man and team $300 \times \$3.50 = \$1,050$, total, $1,530, less 10 per cent of investment, $233; making a net saving per year of $1,297. This is almost 56 per cent saving the first year on the investment.

SAVING MADE IN PLANT NO. 2

In the second plant the storage bin was just outside the boiler-room wall and about 15 feet to one side of the center line of the inlet line in the boiler room. The bin was made of 3-in. plank lined with concrete on furring fastened to the walls and floor.

In this plant the ashes had been drawn from the ashpit to the fireroom floor, loaded into cans and then hauled by a truck to the dump. It took six men to handle the ashes from the fireroom to the truck, with one man filling the cans at the time, and they all worked about two hours a day for the 300 days. In addition the time of the truck amounted to $4 each of the 300 days while hauling these ashes away, which cost was eliminated.

With the new equipment the men's time was eliminated and the time of the truck cost abolished.

The equipment cost us as follows: Ejector equipment, $1,100; storage bin, $1,000; installation, $400; total, $2,500.

We saved the labor of seven men, or 7 × 2 × 300 × 40c. = $1,680, and a truck, or 300 × $4 = $1,200, a total of $2,880 less 10 per cent on the investment, or $250, which left a net saving per year of $2,630.

Another Instance of Saving

In still another instance the storage bin was just outside the boiler room on the center line of the intakes in front of the boilers. The bin was 25 ft. above the boiler-room floor, the latter being in the basement below the yard level.

In this plant the ashes were pulled from the pit to the boiler-room floor, shoveled into cans and then hoisted by hand to the yard level. From there they were dumped into a cart and hauled away. This took two men and a truckman's time to the amount of $7.24 per day for 300 days per year, or $2,172, which expense was eliminated.

The equipment cost was: Ejector equipment, $1,100; storage bin, $1,000; installation, $400; total, $2,500.

We saved, as stated, $7.24 on three men and a team, or 300 × $7.24 = $2,172 less 10 per cent on investment, or $250, making a net saving per year $1,922.

In each of these installations after putting in the ash-removal system the one fireman on watch was able to remove all the ashes without help and not do any more work than he had done before. Formerly, he cleaned his own fire and cleared the ashes from the ashpit. Now he does the same, and while cleaning the ashpit he cleans into the intakes of the ejector system, and by the time he is through cleaning a fire or ashpit the floor is clear, but for sweeping the overflow into the intakes, where it disappears out of his way.

How the System Works

This system of ash removal will work well with boiler pressures as low as 70 lb. The higher the pressure the better it will work.

The ashes can be raked into the intakes at any size that will enter the opening. Hot or cold ashes can be handled in this system, but it works best with dry ash; it will handle wet ashes as well if they are not too fine. A very fine ash from the back connections should be handled dry.

Any refuse to be ejected by the system should not be drawn into the intakes until the steam is turned on to the ejector and it is working to its fullest capacity.

The 10 per cent subtracted from the savings in the instances given is alloted 6 per cent for interest and 4 per cent for upkeep. For the reason stated the upkeep is very small. There is, of course, an operating cost for the steam used in operation, but as this is hard to estimate owing to the very small operating time per year and as it will be small, it is not included.

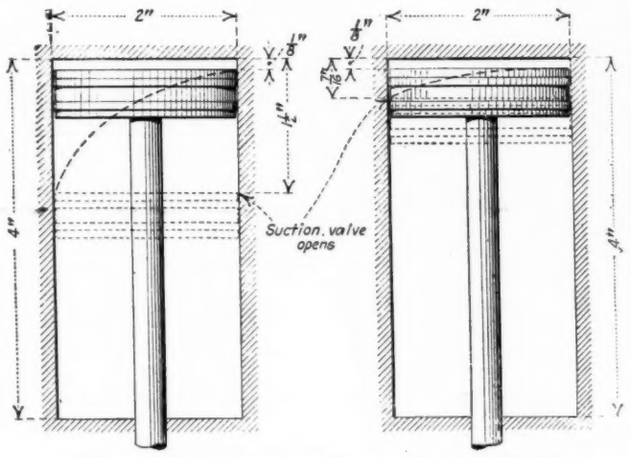
These systems have certainly shown a great saving compared to the investment in each case and the operation cost will not detract from this materially. Other advantages are a cleaner fire-room floor and the absence of ash cans.

Some Notes on CO_2 Refrigeration System

By F. T. Flenniken

It is well known that the theoretical efficiencies of the CO_2 and ammonia systems, when used for cold-storage purposes, are equal. In practice, however, other factors exert considerable influence. The two sketches represent two cylinders, each with a 2-in. bore and a 4-in. stroke and both having $\frac{1}{8}$-in. clearance between the piston and cylinder head; the ammonia is on the left. The condenser pressure secured would be about correct with 65-deg. cooling water.

It can be seen that the re-expansion of ammonia in the clearance space prevents the suction valve opening until the piston has traveled down $1\frac{1}{2}$ in. in 37 per cent of



COMPARISON OF CO_2 AND AMMONIA SYSTEMS

the stroke. The maximum obtainable efficiency with light rings and valve is only 63 per cent.

With the CO_2 cylinder the suction valve opens when the piston is only $\frac{7}{16}$ in. on its stroke; the volumetric efficiency is, then, 89 per cent. To be sure this example is an exaggerated one since no cylinder of this size would have such a large clearance; however, it serves to show the relative effect of clearance volume when using the two media. Owing to the smaller size of the CO_2 cylinder the difference is more apparent in the actual machine. Actual tests show 1.1 hp. per ton, while 1.3 hp. per ton is good results from an ammonia system.

There is a belief among many engineers that the efficiency and capacity of the carbon-dioxide system show marked decreases when the cooling water is over 80 deg. F. There is, of course, a decrease with both media, but it is less noticeable with the CO_2. The critical temperature of CO_2 is supposed to be 90 deg. F., but the writer installed and operated such a plant in Texas where the cooling water was always above 92 deg. and owing to a limited supply the discharge was often as high as 120 degrees.

Engineers should study both the carbon-dioxide and ammonia systems, for the latter is the main dependence in the merchant marine and is coming into favor in stationary work.

Modern Hydraulic Turbines—Requirements and Tests on Models*

Present Tendency in Hydraulic-Turbine Design Is Toward High-Capacity Machines —High Efficiency, Reliability and Durability Are Important Requirements in Hydraulic Turbines—Special Care Must Now Be Given to All Parts of the Hydraulic Installation

By FRANK H. ROGERS
Hydraulic Engineer, I. P. Morris Department, The Wm. Cramp & Sons Ship and Engine Building Company

THE attempt to meet the present immense power demand in this country by large central stations interconnected electrically results in the case of hydro-electric units in the following important requirements: (1) High-powered units; (2) high speed; (3) high efficiency; (4) reliability; (5) durability. These requirements demand hydraulic turbines of highly specialized design, and hence, except for occasional small installations, the day of the "standard" or "stock" turbine is past.

Usually the first cost of the hydro-electric station is high as compared with the steam station, but the operating cost is much lower, hence the success of the investment depends upon keeping the first cost as low as possible and securing continuous maximum power output of the plant at low operating expense.

High-Powered Units

The first cost of the power station per horsepower can be reduced by installing large-sized, high-powered units, thus reducing the number of units required in the plant. Some years ago this was impracticable owing to the operating conditions. Then each station was independent and had to be designed to take care of variable-load requirements on two, three or more independent transmission lines. This necessitated installing a large number of small units—eight, ten and sometimes twenty turbines in a single plant. Today conditions are changed. Large plants are now interconnected electrically, supplying energy to a great many industries over a vast area, resulting in the average demand being much more uniform. Today an entire power plant bears to the whole system about the same relation as the single unit to the independent plant a few years ago. In modern plants, therefore, large high-powered units are required, and very often the size is limited only by the railroad shipping clearances. It is not unusual to find but four or five units, and in some cases but a single unit, in a modern plant.

The present tendency toward large-sized, high-powered turbines is illustrated by the units shown in Figs. 1 to 5. Twelve of the units shown in Fig. 5 are now in operation, and their large size can be appreciated from the fact that each turbine requires at full load about 3,600 cu.ft. of water per second and weighs, complete, about 1,250,000 lb. The speed-ring casting, Fig. 2, stays the throat of the concrete casing and is also designed to support the weight of the generator, complete rotating parts and a portion of the concrete. The use of a metal speed ring built into the concrete substructure in combination with a concrete volute casing was first developed by H. B. Taylor, of the Cramp company, in 1911 for the 6,000-hp. turbines built for the Appalachian Power Co., New River, Va. Since that time this construction has been universally adopted as standard practice for vertical units under low and moderate heads.

A comparison is shown of one of the 37,500-hp. units in extension to plant No. 3 of the Niagara Falls Power Co., and one of the 55,000-hp. turbines for the Queenston Development of the Hydro-Electric Power Commission of Ontario in Figs. 3 and 4 respectively. For a complete description of the Niagara Falls Power Co.'s development see *Power*, Sept. 14, 1920. Three turbines as illustrated in Fig. 4, are now under construction by the William Cramp & Sons Ship and En-

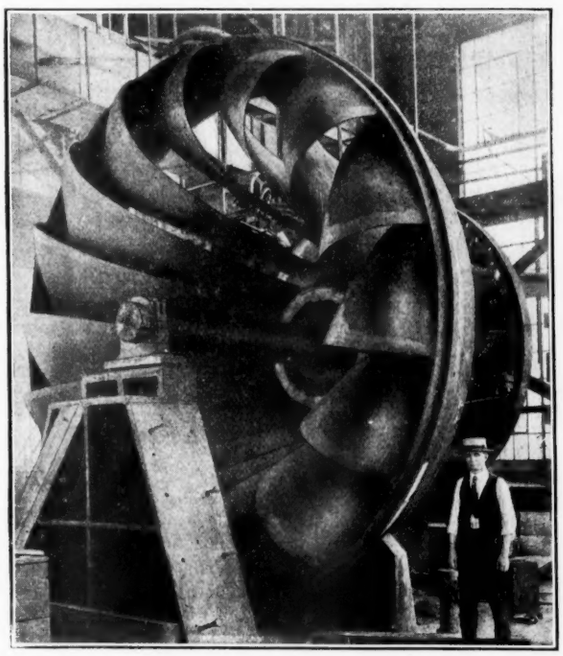


FIG. 1. CAST-IRON RUNNER FOR CEDARS UNITS, FIG. 5. MAXIMUM DIAMETER, 17 FT. 7 IN. WEIGHT 167,000 POUNDS

*Paper presented at a joint meeting of the Engineers Club of Philadelphia and the Philadelphia sections of the American Society of Civil Engineers, American Institute of Electrical Engineers and American Society of Mechanical Engineers.

gine Building Co. Two units of similar capacity are being built by the Wellman-Seaver-Morgan Co.

Fig. 6 illustrates graphically the total water power developed in the United States to date and the large increase in unit capacity from 1890 to 1921.

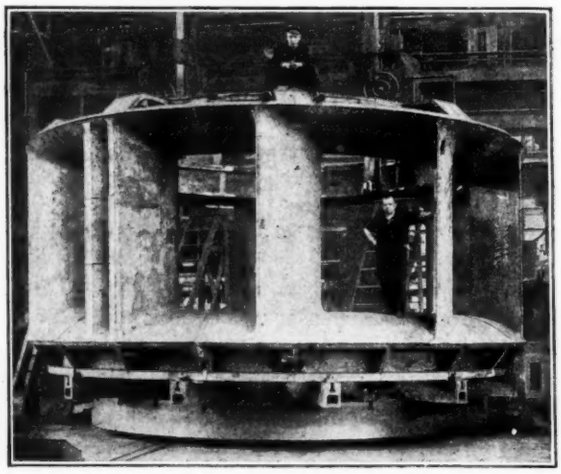


FIG. 2. SPEED RING FOR CEDARS UNIT, FIG 5. OVERALL DIAMETER, 25 FT. WEIGHT, 190,000 POUNDS

High Speed

High speed is an even more important factor than high power for reducing the first cost, not only because high speed results in a reduction in the size of the turbine and generator but because it permits simplification in the design of the turbine, particularly in the case of low-head installations. In the East the low-head developments predominate, and with the available designs of runners a few years ago to obtain reasonable generator speeds it was necessary to build multi-runner turbines, often as many as six runners on a shaft. Such a unit required six sets of guide vanes, interconnected operating gear, four or more bearings, etc. Such a multiplicity of parts greatly increased the first cost and operating expense. With the modern development of the high-speed runner such complicated designs were replaced by single-runner, vertical-shaft units with simple and few parts, greatly reducing the first cost and operating expense and at the same time resulting in much higher efficiency.

The turbine shown in Fig. 8 was built in 1906 and is of the three-runner, vertical-shaft type of comparatively low specific speed. The turbine in Fig. 9 was built in 1919 and is of the vertical-shaft, single-runner type of high specific speed. This turbine under a head of 70 ft. will develop about 8,500 hp. at a speed of 145 r.p.m. and is therefore very closely comparable to the West Kootenay unit, Fig. 8. The advantages of the single runner, as compared with the three-runner unit as to first cost, operating expense and efficiency, are self-evident. A particularly interesting example of the advantages of high speed is shown in the plant of the Pennsylvania Water and Power Co. at Holtwood, Pa. In 1910 five units were installed in this plant of the two-runner, vertical-shaft type, Fig. 10. The plant was originally laid out for nine units of this type, the head works and concrete draft tubes being built for the entire installation at this time. However, in 1914, when the eighth unit was installed, it was decided to change to the single-runner, high-speed type of design, Fig. 11, which resulted not only in a very considerable saving in first cost but also in a great gain in efficiency. Tests made after installation showed a maximum efficiency of 93 per cent for No. 8 unit, as compared with 83 per cent for the old two-runner units.

High Efficiency

The total yearly output of a hydro-electric plant is a direct measure of the revenue income, and where the flow of the river is limited or suitable storage reservoirs are installed to impound water during flood periods, the efficiency of the turbine is a direct measure of the yearly power output. Today it is generally considered economical to develop a site completely and to build storage reservoirs to more nearly equalize the flow throughout the year, resulting in a minimum waste

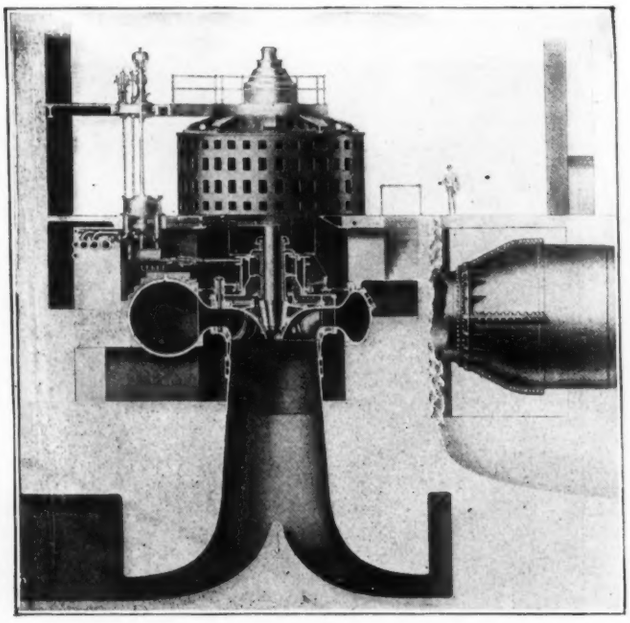


FIG. 3. NIAGARA FALLS 37,500-HP. UNIT

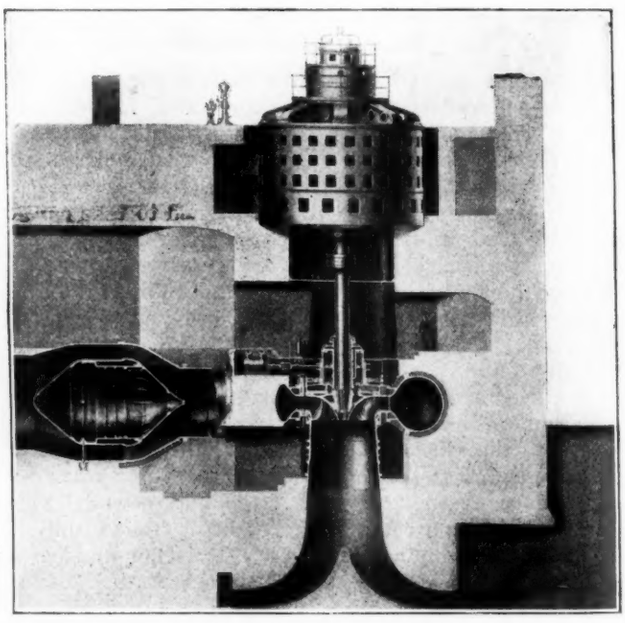


FIG. 4. QUEENSTON DEVELOPMENT 55,000-HP. UNIT

of water. In the case of international streams such as the St. Lawrence and Niagara Rivers the exact amount of water that can be used by each country is governed by treaties, and hence the amount of power that can be developed on such streams is directly proportional to the efficiency of the turbines. For this reason turbine manufacturers have spent a great deal of time and money in experimentation, at the Holyoke flume and in their own laboratories, in order to secure the highest possible efficiencies. Due credit for the advances made along this line should be given to the power companies, who, realizing the economic advantages of securing high efficiencies, have in the past offered large bonuses to the

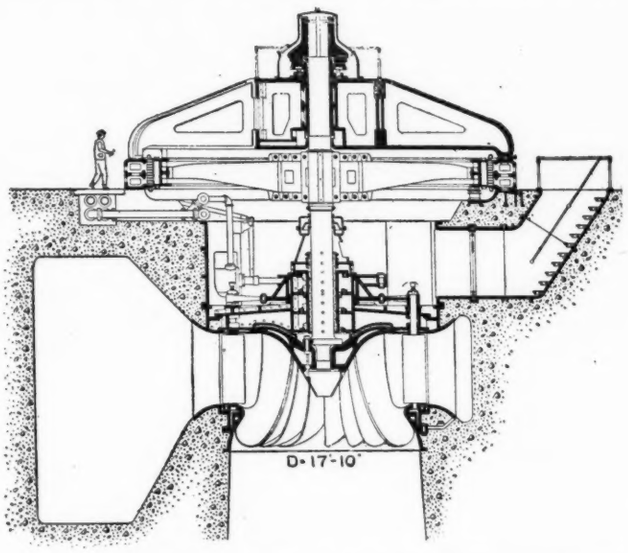


FIG. 5. TURBINE CEDARS PLANT OF THE MONTREAL LIGHT, HEAT AND POWER CONSOLIDATED. HEAD, 30 FT. SPEED, 55.6 R.P.M.

manufacturers for exceeding their guarantees of efficiency, amounting in some cases to $1,000 for 1 per cent on each turbine.

In comparing the curves shown in Fig. 7 it should be noted that not only have the points of maximum efficiency been considerably increased but the part-gate efficiencies to an even greater extent, so that very flat efficiency power curves are now secured, which are particularly advantageous in plants where it is necessary to operate the units at times at part loads.

Reliability

Little need be said on the point of reliability of operation, as this quality is required in all types of machinery. It might be pointed out, however, that if for any reason a large hydraulic turbine is shut down for inspection or repairs a loss in power output results without any saving whatsoever to the power company, as in the case of a hydro-electric plant there is no "coal pile to save." If a large turbine is out of commission even for a short time the revenue loss to the power company runs into large amounts. Thus in the case of a plant containing 30,000-hp. units, on the basis of a sales price of $15 per horsepower year, there would be a loss in revenue of $1,200 a day for each day that one of the units is out of commission.

As a record of continuous operation it might be interesting to state that several of the 10,800-hp. units in the Cedars plant of the Montreal Light, Heat and Power Consolidated have been in continuous operation day and night for a period of 30 months, without even shutting down the units for inspection. Strength and sturdiness of design are therefore of importance, but these features should be combined with simplicity, so

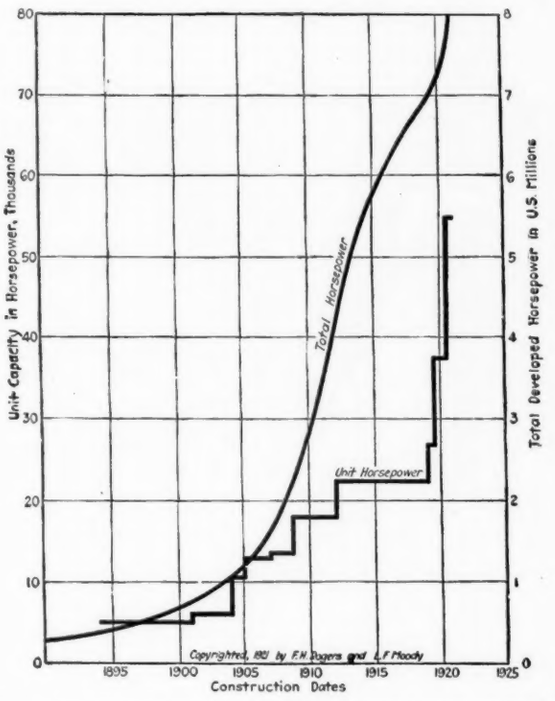


FIG. 6. PROGRESS CHART OF THE HYDRAULIC TURBINE; 1890 TO 1921

that if the occasion arises the unit may be dismantled, repaired and assembled in the shortest possible space of time.

Durability

Owing to the high first cost of the hydro-electric station durability or long life of the turbines is a vital asset in determining the success of the investment. The

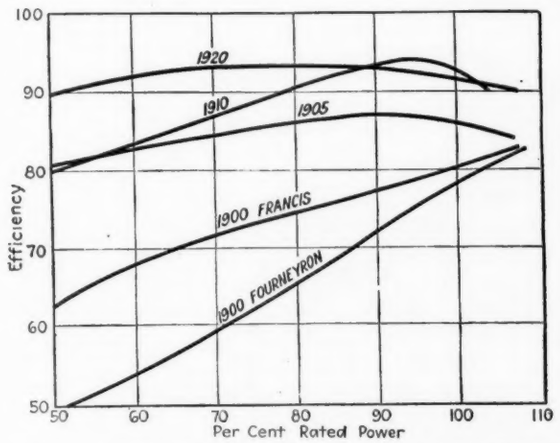


FIG. 7. ADVANCE MADE IN HYDRAULIC TURBINE EFFICIENCY FROM 1900 TO 1920

modern type of vertical-shaft turbine, whether of the concrete or metal volute-casing type, is buried in the concrete substructure of the power house, and the cost of replacing the entire turbine would be almost prohibitive. A turbine might develop extremely high efficiency

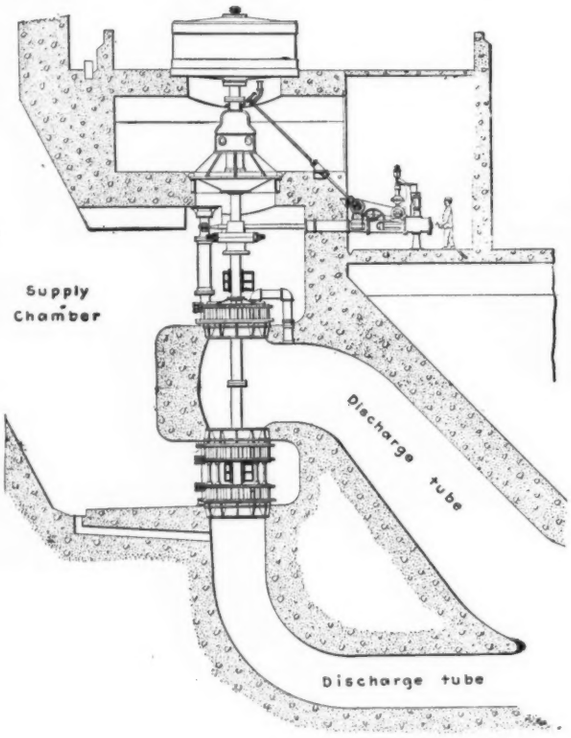


FIG. 8. TURBINE 8,000 HP., EAST BONNINGTON FALLS PLANT, WEST KOOTENAY POWER AND LIGHT CO., BRITISH COLUMBIA, CANADA, OPERATING UNDER A 70-FT. HEAD AT 180 R.P.M.

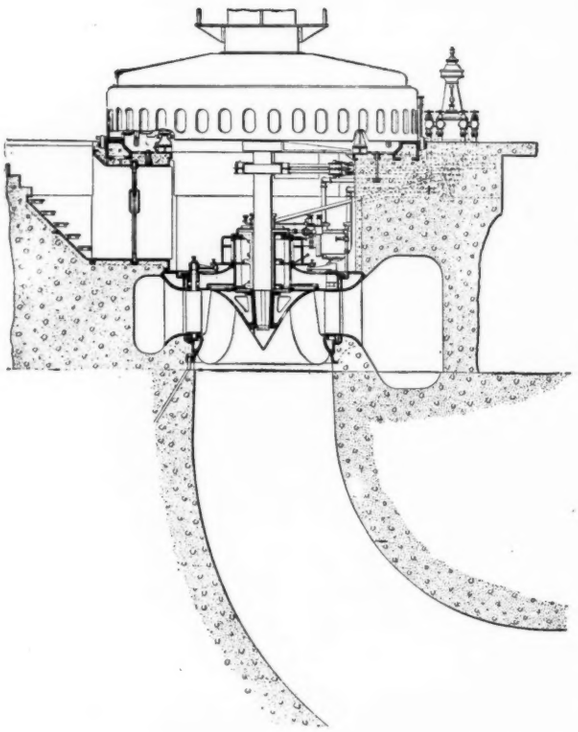


FIG. 9. TURBINE 6,000 HP. IROQUOIS FALLS PLANT OF THE ABITIBI PULP AND PAPER CO., ONTARIO, CANADA, OPERATING UNDER A 55 FT. HEAD AT 128.5 R.P.M.

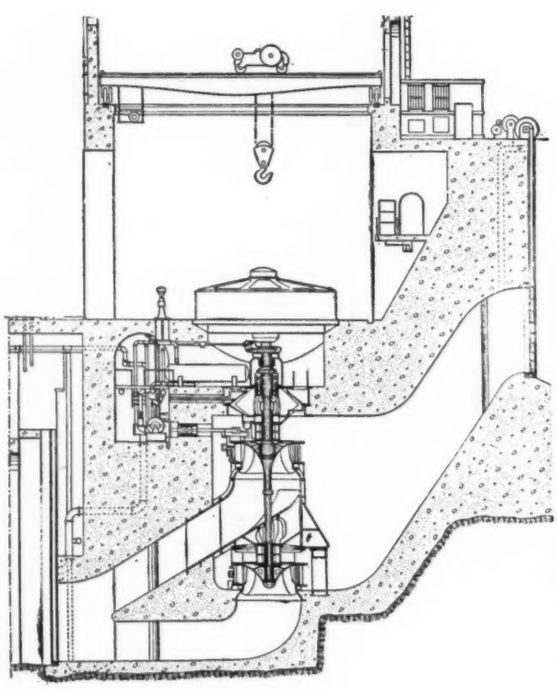


FIG. 10. TURBINE, 17,000-HP., HOLTWOOD STATION OF THE PENNSYLVANIA WATER AND POWER CO., OPERATING UNDER A 63-FT. HEAD AT 94 R.P.M.

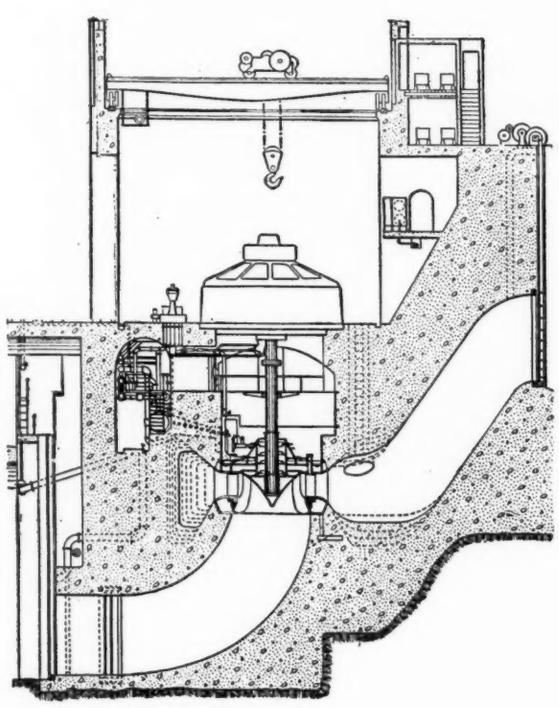


FIG. 11. TURBINE, 16,500-HP. UNIT NO. 8 OF THE PENNSYLVANIA WATER AND POWER CO., OPERATING UNDER A 63-FT. HEAD AT 94 R.P.M.

and operate in a thoroughly reliable manner for one or two years, but if at the end of this period it completely broke down the installation would certainly be a failure both mechanically and economically.

In the design and building of hydraulic turbines the severe conditions under which they operate must be carefully considered. In many plants a great deal of foreign matter, such as ice, wood, sand, etc., passes through the wheel at certain periods of the year. During the winter season it is often necessary, in order to keep the wheels in operation, to raise the racks and thus let large quantities of ice carrying other foreign material pass through the casing, guide vanes and runner. Variations in load on the generator causing the governor to move the turbine gates result in changes in hydraulic pressure within the turbine. Considerable speed changes follow large load changes and runaway speed may result from governor trouble. To meet the foregoing conditions the question of fatigue of materials must be studied and extremely low stresses used in all parts of the machine.

Tests on Models as an Adjunct to Design

Some years ago the design of the runner was considered the most important item, and little care was given to the design of other portions of the turbine and water passages. For this reason model runners were tested at the Holyoke testing flume at Holyoke, Mass.,

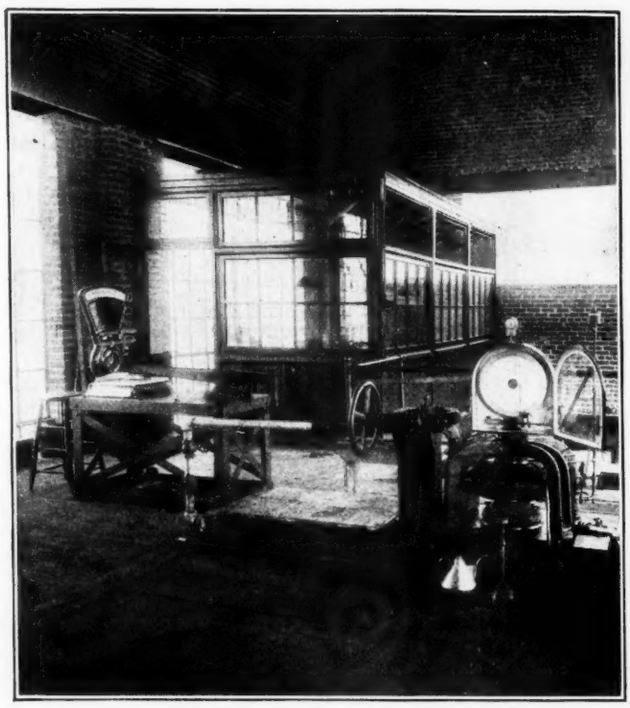


FIG. 12. ALDEN DYNAMOMETER AND SCALES IN HYDRAULIC LABORATORY

and although extremely good results were obtained on the runners, after installation in a particular setting the performance of the turbine as a whole, often did not come up to guarantees. It is now fully appreciated that special care must be given to the design of all parts of the hydraulic installation; that is, intake, canal, forebay, racks, penstock, surge tank, main valve, casing, guide vanes, runner, draft tube, and tailrace.

Completely equipped laboratories have been built in recent years for testing the entire hydraulic layout. Figs. 12 and 13 show views of the I. P. Morris hydraulic laboratory on Petty's Island in the Delaware River. This building is equipped with a concrete headrace, tailrace and return tanks. The water is pumped by means of motor-driven centrifugal pumps into the

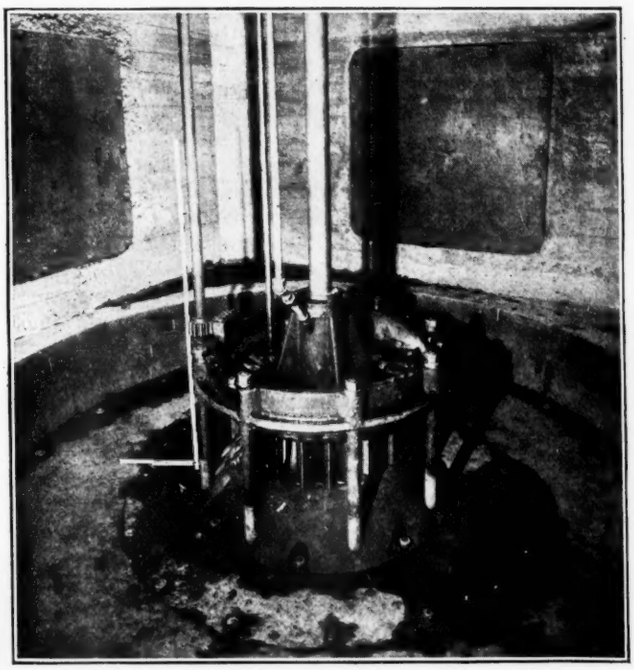


FIG. 13. TURBINE MODEL IN HEADRACE TANK

headrace tank, where the model turbine is located, and after passing through the turbine, the water flows through the tailrace tank over a weir and back by the return tank to the suction of the pumps. Model runners 16 in. in diameter may be tested in this laboratory under heads up to 12 ft. in conjunction with various type of intakes, casings and draft tubes. The effective head on the turbine is measured by differential gages attached to the headrace and tailrace tanks. The quantity of water is measured by means of a weir carefully calibrated by the volumetric method. The power is measured by an Alden dynamometer and direct-reading scales shown in Fig. 12. All readings are taken simultaneously at half-minute intervals by means of signal bells controlled by a master clock. In this laboratory it has been possible to make comparative tests of the same runner with different forms of draft tubes, all other conditions being the same, and by this means arrive at an exact comparison of the different draft tubes used.

The second part of this paper, which treats general and special features of design, will appear in the April 19 issue.)

When two or more boilers are connected to a common header each boiler should be protected with a non-return valve. As a safety-first measure this is a necessity. Such a valve will automatically cut out the boiler on which it is placed in the event of a tube bursting, thereby reducing the pressure and preventing the steam from the head from flowing into the boiler on which the accident occurred.

Tests on Lubricating Oil for Two-Stroke-Cycle Semi-Diesel Engines

By T. M. ROBIE

ONE of the most important points to consider in the operating of any machine is its lubrication, and the oil engine is no exception to this rule. In fact, internal-combustion engines present a more difficult problem than any other type of machine, owing to the exceedingly high temperatures that are encountered.

There are a surprisingly large number of oils on the market, supposedly suitable for oil engines. These range in viscosity from 200 to 2,000 seconds at 100 deg F. and from 40 to 120 seconds at 210 deg. F., taken with the Saybolt viscosimeter. The average engine buyer knows little concerning the relative merits of any of these oils. He too often chooses an oil simply because his neighbor, who may have an entirely different kind of engine, is obtaining good results.

The lubrication of each part of an engine requires separate study. The temperatures to which the bearing surfaces are subjected play an important part, as do the pressures and speed. For instance, an oil that may be entirely suitable for the comparatively low temperatures of the main and crankpin bearings, might be of too low viscosity to prevent metallic contact or scoring in the cylinder.

This leads us to a consideration of the change in the viscosity of an oil, with an increase in temperature. Fig. 1 shows curves for several different oils and clearly illustrates the changes that take place. It should be noted that the viscosities for temperatures above 250 deg. F. vary only by a few seconds.

Engine manufacturers are beginning to realize the necessity of being able to definitely recommend whether or not an oil will be suitable for their particular type of engine, and a purchaser should always consult the manufacturer before ordering his lubricating oil. Owing to the large number of oils on the market, it might even be necessary to submit for actual test the most available oil of the grade required.

The problem of properly lubricating the two-stroke-cycle engine of the inclosed-crankcase type, having cylinders up to 50 b.hp. in size, is probably as difficult as any that will be encountered. Engines of this type are, for the most part, in more or less isolated installations, and their size would hardly warrant the use of two separate oils, one for cylinder and the other for bearing lubrication. Since, as previously noted, the characteristics for these two classes of service are not necessarily the same, it remains to select an oil that will give low bearing friction, but at the same time have sufficient viscosity and other necessary qualities to function properly as a cylinder lubricant.

In order to be able to make definite recommendations on oils for use in an engine of the two-stroke-cycle, inclosed-crankcase type, a well-known engine manufacturer went into the question rather deeply.

A brief description of the engine will be in order. A single-cylinder vertical engine was chosen, the load being applied by means of an improved type of prony brake having a water-cooled brake wheel to overcome the possibility of excessive heating with resulting sticking of the brake. The main bearings were ring-oiled. The crankpin bearing was fed from a mechanical lubricator by means of a centrifugal oil ring fastened to the crank cheek and a hole through the crankpin. The oil for the piston-pin bearing was scraped off the cylinder walls, a special feed from the lubricator being provided for the purpose. The main feeds to the cylinder were two in number and were also supplied from the mechanical lubricator.

It was necessary to formulate a test that would give accurate information by which the various oils could be judged. The first question was one of time—how long a test would be required. A test of seventeen hours' duration was finally adopted. While this may seem a short period to some operators who think in terms of months rather than hours, the results showed that in this time the characteristics of an oil could be quite definitely determined. The next question to be considered in outlining the test was one of load. It was decided to run at absolutely no load for nine hours and at full rated load for eight hours, each of these runs to be continuous. The no-load run would show up any tendency for the oil to "gum up" the piston, while the sustained full-load test would indicate the heat-resisting qualities.

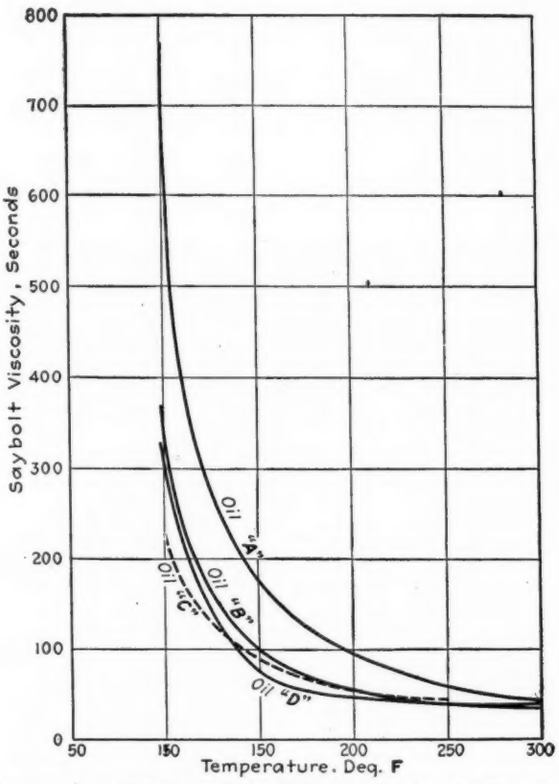


FIG. 1. INFLUENCE OF TEMPERATURE ON VISCOSITY OF LUBRICATING OILS

The fuels chosen were kerosene for the no-load and distillate for the full-load runs. These fuels were chosen on account of their homogeneity and because experience had proved that these oils burned with

absolutely no carbon formation. It would thus be a more simple matter to determine the carbon-forming tendency of the lubricating oil under test. The temperature of the outlet cooling water was maintained at approximately 150 deg. F. during the tests. Half-hourly readings were taken of the fuel consumption, speed, and the following temperatures: Inlet and outlet cooling water, room, and the main bearings. The bearing temperatures were taken with thermometers in putty pockets placed directly on top of the bearing shells. At the end of each run the temperatures of the piston-pin and crankpin bearings were taken.

At the end of the eight-hour full-load test the piston was removed and the condition of the piston and cylinder was noted. The parts were then thoroughly cleaned and the engine reassembled. In order to ascertain that the engine was in mechanically good order, a reference test was run at frequent intervals, on an oil that was known to be suitable. This test followed the outline already given, and the results were considered a criterion by which the other oils were judged.

A laboratory test was made at the same time as the engine test, so that it was possible to correlate the two results. The laboratory determinations included the specific gravity and degrees Baumé at 60 deg. F.; the flash and burning points; the Saybolt viscosity at both 100 and 210 deg. F. (in some cases the viscosities at 150 and 250 deg. were also taken); the congealing point, the percentage of sulphur and the percentage of free acid.

In the testing of over sixty lubricating oils some very interesting points were brought out. In judging an oil, consideration was given to the bearing temperatures, fuel consumptions and internal appearance of the engine after the test.

The gravity of the oil seemed to have little influence on the performance and was more indicative of the locality from which the crude oil was obtained than of the quality of the oil.

It was found that viscosity had a decided influence on both the bearing temperatures and the fuel consumptions. In general, it seemed as if the carbon formation was heavier with the high-viscosity oils, although there were several notable exceptions. The following table indicates the effect of viscosity on the carbon formation:

Saybolt Viscosity at 100 Deg.	Total Number of Oils Tested	Number Giving Small Amount of Carbon	Percentage Giving Small Amount of Carbon
200-300	14	11	78.5%
300-400	16	4	25
400-500	9	2	22
500-600	9	3	33
600-700	10	1	10
700-800	5	1	20
800-above	7	3	43

The results would indicate that the laboratory test as outlined is insufficient to enable anyone to foretell accurately what will be the performance in an engine. The problem of developing an adequate laboratory test for carbon is one deserving of careful study, as there is considerable doubt expressed that the present carbon residue tests are altogether satisfactory.

The effect of the viscosity on bearing temperatures is another item worthy of note. With an oil of high viscosity the temperature rise is much faster and the final constant temperature (usually reached after about five hours of running) is higher than with an oil of lower viscosity. Since any additional temperature in the bearings represents increased friction, it may be understood why an oil of low viscosity will give the best mechanical efficiency, provided, of course, that the viscosity is sufficient to prevent metallic contact.

The curves of Fig. 2 will show the effect on temperature of using oils of different viscosities in the same bearing and under the same load, speed and room-temperature conditions.

While the matter of viscosity is under discussion, it would doubtless be well to mention the question of filtering. By this means a considerable amount of oil which would otherwise be lost, may be completely reclaimed. There are a number of filters of different

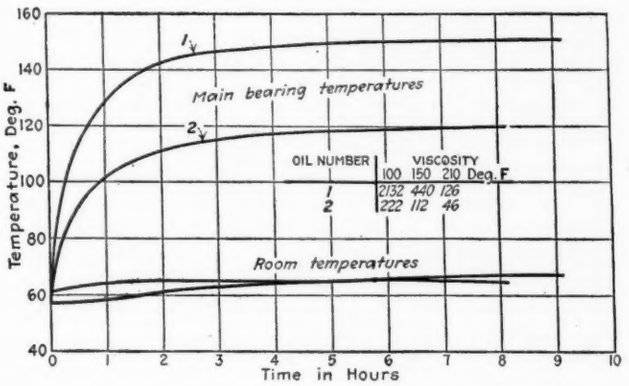


FIG. 2. VARIATION OF MAIN BEARING TEMPERATURE WITH LUBRICATING-OIL VISCOSITY

types on the market, but it may be generally said that the oils of higher viscosity are not as easily filtered as the lighter ones. In fact, with some types it is impossible to filter the heavier oils without preheating them.

The flash points of the oils tested varied from 310 to 480 deg. F., and apparently bore no definite relation to the viscosity. For instance, in the oils having viscosities between 200 and 300 seconds at 100 deg. F., the flash points varied from 310 to 405 deg. F. Similarly, with the carbon-forming tendency, the flash point had no noticeable effect. However, no trouble should be expected due to flash point alone, when this is above 250 deg. F., which is about the inner skin temperature of the cylinder walls when the jacket-water temperature is in the neighborhood of 160 deg. F.

There is a fairly constant relation between the flash and burning points, so that what has been said of one will hold, in a large measure, for the other. The burning point forms a rough check on the flash-point determination, but otherwise possesses little value, and many laboratories are discontinuing the test.

The congealing point of the oil is of some importance, especially in engines exposed to excessive cold. However, it is always possible to warm the oil for the lubricator prior to starting the engine, and with ring-oiled main bearings the supply of oil is quite positive. Generally speaking, any oil with a congealing point below 25 deg. F. should be entirely safe.

The percentages of sulphur and free acid in any well-refined oil are negligible, and but little attention was paid to the laboratory determinations of these quantities, as they had no noticeable effect on engine performance. The sulphur ran as high as 0.5 per cent in some cases, while the percentage of free acid was rarely over 0.3 per cent. The ill effects of an excess

of either of these constituents would be shown only after long usage in the corrosion of the metals with which they come in contact.

To sum up the foregoing results, it would seem that viscosity plays the most important part of any of the measurable quantities in judging an oil. For the particular kind of engine used in these tests it appears that an oil having a viscosity of from 200 to 500 seconds at 100 deg. F. would give the best results, considering both the bearing and cylinder lubrication. It does not follow, however, that every oil having a viscosity between these limits would be suitable, and an actual engine test is the safest means of judging. This should preferably be conducted at the factory where load and temperature conditions are accurately known, as well as the mechanical condition of the engine.

Radiant Energy in Boiler Practice

By A. G. Christie

It is a well-known physical fact that an exchange of heat may occur between two bodies of different temperatures without heating the intervening medium. Thus the heat from the sun may be absorbed by a pot of water after having passed through the space between the earth and sun and even through a plate of glass, without heating either atmosphere or glass. This heat is called radiation and is said to be transmitted as radiant energy between the two bodies. It is generally believed that this energy is transmitted by some form of wave motion. Furthermore, certain substances, like glass, are transparent to certain wave lengths and readily transmit this radiant energy. Other substances, like water, absorb practically all these heat waves. In general, bad radiators are good reflectors, and if a body reflects a large amount of the radiant energy it receives, it absorbs little. Thus white surfaces absorb very little radiant energy, but reflect a large portion of it. Polished surfaces are likewise poor radiators and good reflectors. On the other hand, dull black surfaces are the best absorbers and the poorest reflectors. Stefan discovered that the rate of radiation or transmission of radiant energy between two bodies is proportional to the difference between the fourth power of the absolute temperature of the emitting body and that of the receiving body.

Of the total heat transferred in a boiler from the coal to the water, the proportion transmitted as radiant energy in a properly designed setting is an important factor. This is shown by the large amounts of steam formed in tubes directly over the fire. The glowing fuel bed in the furnace radiates energy to the furnace walls and to the exposed boiler surfaces. The furnace walls, being of firebrick and therefore poor conductors, become incandescent at their surface by the absorption of this energy. They therefore receive no further energy from the fire until cooled by the loss of some of their energy by radiation to exposed boiler surfaces. If the boiler surface is clean, its color is usually a dull black or brown and such surface is a good absorber of heat. It is assumed that the radiant energy is transformed into heat at the boiler surface on being absorbed and is then carried through the metal to the water inside by conduction.

A matter of great importance to the engineer is the amount of boiler surface placed so that it can receive direct radiation from the fuel bed and side walls. Some of the old internal flue boilers gave remarkably good economy because a very large surface was exposed to direct radiation. In Chicago it was found that return-tubular boilers equipped with a certain smokeless furnace with a full arch over the fire and under the boilers gave lower efficiencies than when the arch was removed, because the full arch intercepted the radiant energy from the fire bed. It is therefore desirable to have the greatest possible amount of boiler surface exposed to the fire so as to receive the direct radiations therefrom.

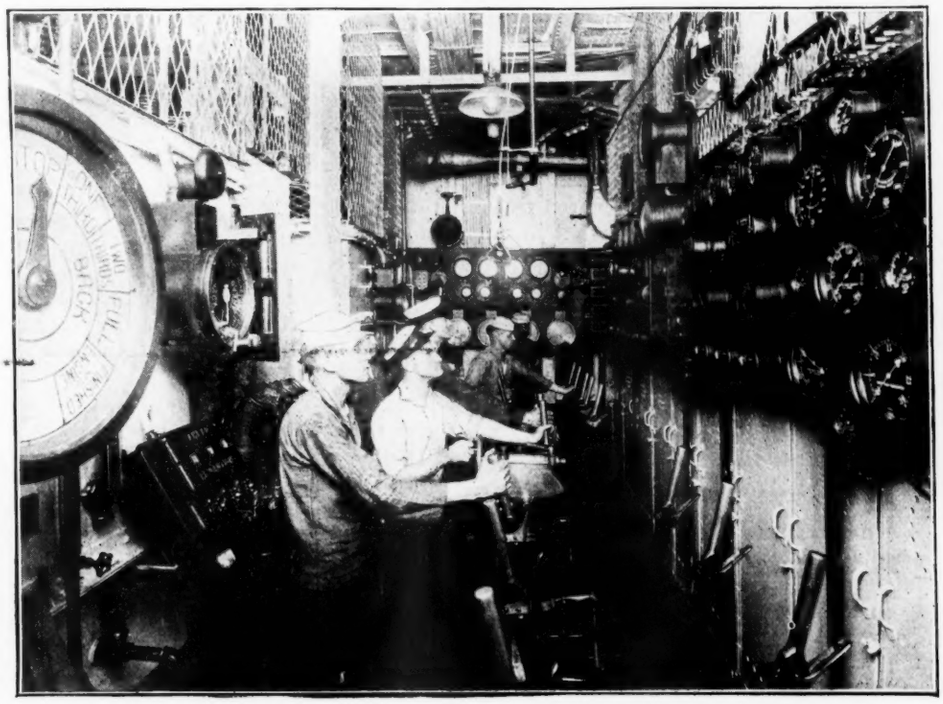
The next factor of importance is that the boiler surface be in a condition to absorb as much as possible of this energy. A coating of fine white or gray ash will not only keep the hot gases rising from the furnace from coming in contact with the tubes, but will absorb less radiant energy than the clean, dull-black surface. Hence the importance of clean boiler tubes and the usefulness of boiler soot blowers.

Since the radiant energy transmitted varies as the difference between the fourth power of the absolute temperatures of the fuel-bed surface and the boiler surface, the importance of high temperature at the surface of the fuel bed is at once apparent. When a fuel bed becomes covered with ash and cinder, as is frequently the case with an underfeed stoker, it is apparent that its power to radiate energy has been appreciably diminished. It is therefore desirable to have clean hot fuel beds at the highest possible surface temperature.

The foregoing considerations of radiant energy and radiation as related to boiler practice lead to the following conclusions: First, that direct radiation is an important source of heat in boiler furnaces which should be carefully considered in both design and operation; second, that the highest possible furnace and fuel-bed surface temperatures should be maintained, so as to emit the greatest amount of radiant energy; and that furnace design and operation should be studied to insure continuous removal of ash and cinder from this hot surface; and third, that the greatest possible amount of dull metallic boiler surface should be arranged to "see" the fire; that is, to receive this radiant energy directly, and that these surfaces must be kept free of dust and cinders by effective cleaning devices. All three of these considerations are important factors in efficient boiler operation. What study is being given in your boiler plant to the most effective use of the radiant energy that is available in the furnace?

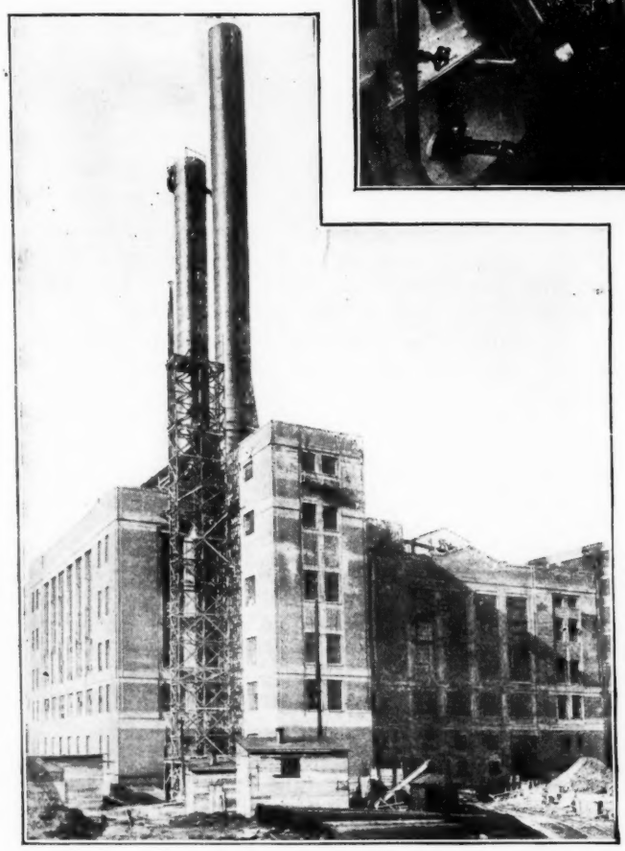
The properties of steel and many other alloys are largely determined by three factors: Composition, including structure; heat treatment, and mechanical treatment. On account of the lack of suitable apparatus for the investigation of the last-named factor, this subject has received rather scant attention in the experimental study of steel. For this reason quite an elaborate study of the rolling of steel has been undertaken by the Bureau of Standards where the special facilities, such as a small rolling mill, have proved of great value. Investigation has been completed as far as rolling operations are concerned, and the test specimens are now being prepared for the different mechanical tests which, together with other examinations, such as metallographic, will be used as a measure of the effect of the various factors that enter into the mechanical treatment of metals.

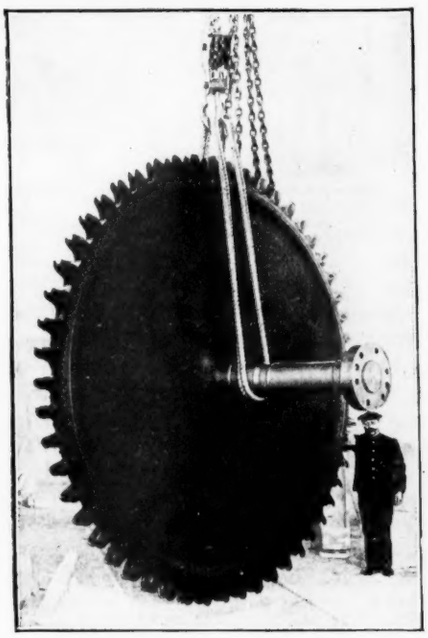
A remarkable blister practically closed this piece of 2-in. welded pipe, which was part of the return piping of a heating system. It tested out satisfactorily when installed in the summer but gave no end of trouble when cold weather brought a large flow of condensate. The end view at the left, which was taken at the middle of the blister, shows clearly how small a passage was left. The heavy black line in the end views indicates the position of the weld and the lighter lines show where the pipe was cut longitudinally to make possible the sectional view shown in the center. Note there was no flaw at the weld. This specimen was furnished *Power* by Walter Kidde & Co., of New York, who were called in to solve the mystery of the clogged heating system.



The control room of the U. S. S. Tennessee, America's newest electrically driven battleship. The operation of the steam-electric driving machinery is controlled in this room according to orders received electrically from the bridge. The vessel has recently completed its second trial trip.

Below, the new power plant built by Dodge Bros. at Detroit to run their automobile plant. The ultimate capacity is 40,000 kw. and the cost $3,500,000. Condensing will be effected by a cooling tower that is said to be the largest of its kind in the world.





Right, a 3,000 hp. Pelton wheel, one of four installed at Fully, Switzerland. It is 12 feet in diameter and runs at 500 r.p.m. The net head is over 5,000 ft., one of the highest in existence. The water is directed through a 10-inch pipe horizontally at the bottom of the wheel. A maximum efficiency of 82.3 per cent is reported as the result of tests. The water comes from an Alpine lake 7,000 ft. above sea level through a pipe line that is about three miles long.

Courtesy of the Engineer, London.

Economical Layout for Hydraulic Mining Power Plant

The power plant of the Morris Fertilizer Co.'s Phosphate Rock Mining Plant at Bartow, Fla., has a total rated capacity of 4,250-kva. divided for purposes of flexibility into three 1,250-kva. 19-stage turbo-alternators and two 125-kw. turbine-driven exciter units, which, in addition to supplying excitation for the main units, supply light and power when the latter are closed down. There are two 30,000-sq.ft. capacity surface condensers equipped with intercoolers and radojets. The current generated is 2,300-volt three-phase 60 cycle. The water supply, augmented by an elaborate reservoir system, consists of two 18-in. deep wells located within the power station, supplying 12,000 gal. per min. through two vertical motor-driven centrifugal pumps which deliver the water to the condenser at the uniform temperature of about 72 deg. F.

An interesting feature of the general plant design is that the water from the condensers is drawn into two high-pressure multi-stage pumps driven by a 1,000-hp. synchronous motor delivering 6,000 gal. per min. to the mine hydraulic line at an initial pressure of 220 lb. The water thus delivered to the mining field is used for the operation of ten hydraulic guns, each using from 900 to 1,200 gal. of water per minute. The phosphate material is washed down in solution and removed by high-duty 3,000 gal. per min. centrifugal dredge pumps direct-connected to 200-hp. variable-speed motors, to settling areas where the solid matter contained in the solution is precipitated and clear water delivered to the river.

Universal Coal Conveyor

A comparatively simple system for handling coal from the railway car to the overhead bunker in the power plant or to storage has been developed recently by the Universal Conveyor Co., of South Bend, Ind. It is of the tower-supported trolley design handling 500 lb. of coal at a time and requiring one man to operate it. The

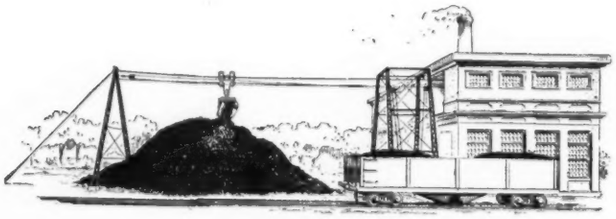


FIG. 1. TYPICAL COAL-CONVEYOR INSTALLATION

average fifty- to sixty-ton drop-bottom car may be unloaded in from 2¼ to 3 hours, depending on the condition of the coal.

Fig. 1 shows a typical installation at a power plant. A tower is placed over the unloading pit to support the track cable, the latter resting on saddles which the side-draft trolley clears.

Coal flows by gravity from the bottom of the railway car into a track hopper, from which the bucket is filled and is elevated out of a shallow pit and conveyed to storage or to the overhead bunker in the boiler house. The track hopper is of concrete construction with a chute portion leading from under the track at an angle of 38 deg. A jackknife gate at the mouth of the chute, operated by the man at the hoist, allows the coal to flow into the bucket or stops the flow when the bucket is out of the pit. For side-dump cars a steel hopper extension from the outside rail is used to direct the flow of coal into the pit.

The bucket, shown in Fig. 2, is of the self-filling, self-dumping and self-righting type. When it comes in contact with the coal pile, the lever shown on the bottom is depressed, allowing the bowl to swing free on its

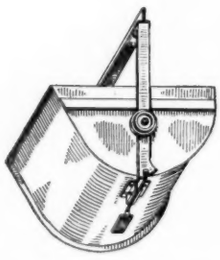


FIG. 2. CONVEYOR COAL BUCKET

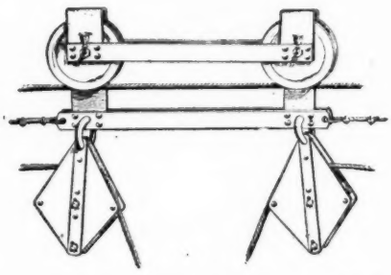


FIG. 3. SIDE-DRAFT TROLLEY CARRIAGE

axis. The weight of the contents, being heavier on one side, causes the bucket to rotate and discharge the coal. When empty, the bowl clears itself and swings back to its normal position, as the over-weight is now on the opposite side. Separate attachments also provide for dumping the bucket from the top, if desired. For reclaiming, a clamshell bucket replaces the regular unloading bucket. The trolley or carriage is of the side-draft type shown in Fig. 3.

The mechanical operation of the system largely centers in a two-drum hoist. A reversible traction drum makes it possible for the operator to send the load in either direction from the hoisting tower. The approximate weight of the hoist is 1,700 lb. It gives a lifting speed of 100 ft. per min. and a traction speed of 300 ft. per min. The hoisting and traction drums may be engaged at the same time, enabling the operator simultaneously to elevate and take out the load.

Connections from headers to engines should be made with a pipe giving a steam velocity not less than 6,000 ft. per min., and preferably 8,000 ft., up to a receiver separator. The cost of the reduced piping plus a receiver separator is in many cases less than if a larger pipe and standard steam separator are used. This is particularly true if the difference in the cost of pipe covering is taken into account. With the smaller piping plus the receiver separator condensation is reduced to a minimum, pipe vibration is invariably eliminated, and leaky flange joints are reduced.

In case one field coil in a direct-current motor or generator has been reversed, the delinquent coil may be detected as follows: Take two nails of such length that, when held end to end, they easily span the gap between adjacent pole tips. With one end of one nail in contact with one pole tip, and one end of the other nail against the next pole tip, there should be a marked attraction between the free ends of the nails. If there is not, the poles are of the same polarity, and one of the two has been reversed.

EDITORIALS

Still on the Toboggan

COAL production as reported by the Geological Survey weekly appears less and less with each report, the inadequate market demand since the middle of January having resulted in a subnormal production of nearly fifty million tons. This is almost as great a loss as was experienced during the entire period of the railway strike at the end of 1919, during which time only about seventy million tons loss in production was recorded. Before the present slump returns to what may be considered normal—that is, about one million eight hundred thousand tons daily—the total under-production doubtless will be far in excess of this seventy million. Some of the possible after effects of this are easy to imagine.

One thing that the buyers of coal should not forget is that the Interstate Commerce Commission evidently does not intend to protect delinquent purchasers by again placing priority orders in vogue. This form of traffic arrangement used during the past year to expedite coal movement certainly cannot be expected again as a relief from the consequences of delayed buying. He who counts upon it will most certainly suffer great disappointment.

The British mine workers' strike which has materialized may also become a factor of considerable importance in the present situation. Our export coal facilities are greatly increased above those available a year ago, and if the foreign purchaser begins to "bull the market" those who have waited to arrange for their next season's fuel supply are certain to find themselves in competition with buyers to whom price is secondary and immediate adequate supply is of first importance. What this means to the price is all too evident from the experience of 1920.

Modern Hydraulic Turbines

ALTHOUGH waterwheels of one form or another are among the oldest of power-producing devices, it is only within comparatively recent years that serious thought has been given to their efficiency. Previous to the introduction of electricity as a power-transmission medium, almost all power-producing units were of small capacity, located near where the power was utilized. As a result the hydraulic turbine was generally built in small units and operated by those who had very limited hydraulic engineering knowledge and gave little thought to the efficiency of the equipment, their chief concern being that the wheel drive the load that it was installed for. How much water it took to do this was of secondary importance. These wheels in the main gave good service so far as reliability was concerned, therefore everybody was fairly well satisfied. Even if it had been desirable to check up the efficiency of a turbine, the difficulty of doing so was sufficient to discourage the attempt in most cases.

However, with the advent of electricity as a power-transmitting medium it became possible to generate power in large bulks at the most favorable locations and transmit it, if necessary, over long distances, to where it is required. This concentration of power generation in large plants has resulted in a number of conditions that have made the reliability and efficiency of hydraulic turbines of paramount importance. Large investments have been made for complete development of water-power sites, not only for the normal flow of the river but for storage capacity, so that the excess water during flood periods may be available during times of low water. In most of these cases stand-by steam plants are used. Therefore every kilowatt-hour that the hydraulic plant develops from the water is one less that will have to be produced by burning expensive fuel. In other cases the quantity of water available is limited by treaty rights or other restrictions; consequently, where power developments are made to use the total available water, the gross income from the investment is dependent on turbine efficiency.

As shown by F. H. Rogers in his article, "Modern Hydraulic Turbines," in this issue, this demand for high efficiency has resulted in remarkable improvements in hydraulic-turbine design. Where in 1900 the highest efficiency developed by a Francis runner at full load was about eighty per cent and at half-load sixty-three per cent, in 1920 these values had increased to over ninety per cent for all loads between fifty per cent full load and ten per cent overload, reaching a maximum of over ninety-three per cent.

The efficiency of the modern turbine is probably about as high as it ever will be, and if the turbine can be constructed to maintain this efficiency over long periods, it will be a highly satisfactory power unit. Some hydraulic turbines are now built that do maintain their high efficiency over long periods, but others have fallen down badly after being in operation for a short time. High efficiency is a very desirable feature, but durability and reliability are of equal importance, for it is upon the latter that the ultimate success of the hydro-electric development depends.

Analyzing Equipment When About To Buy

IT IS a serious matter—putting your "okeh" on a set of purchase recommendations for a particular make of apparatus or on a purchase authorization order for some specific machine or accessory. Friendship alone still plays a strong rôle in this, but it no longer plays the leading part. Sometimes factors other than the merits of the equipment purchased dictate whose goods shall be selected. These, however, are not dragged into the average purchase authorization. By and large in these days the selection is based upon merit of the goods and fairness of the price.

Suppose, for illustration, you need a small generator set. There are many makes available. The sales representative for each builder can put forth a clear, sound argument as to why his set should be selected. But

whose will you select? How will you go about making the selection? Every one of the makers of these machines, it will be assumed, is a reliable, established company employing good engineering and sales talent; and each can point to many machines long in service.

It is not expected of every engineer that he be a designer. Yet it is plain that if he would select judiciously, he must know well what conditions the equipment he is to buy must meet and how well each designer has met them in the product of his company. The point is this: There are certain fundamental physical conditions that every one of these machines must have its design based upon. With regard to the materials of construction there is a wide latitude. How well has the designer done his part? Does the workmanship reflect throughout manufacture that painstaking care so essential to reliability and performance? What is the operating experience of others with these machines? What standing has one builder compared with another, not in size of plant or output, but as engineer and manufacturer?

With accessories, to take another class of equipment, there is far less uniformity in design, quality, business standing, etc. Yet to accessories must the greatest amount of attention be given in operation; from them the greatest annoyance may come. Not that it is impossible for one maker to manufacture as well as another or to employ equally good engineering talent and skill; it is because with some commercialism plays a stronger part than engineering. From a strictly ultra modern, and perhaps Wall-Street-business, point of view, this is all right—there will always be the "Tiffany" shop and the one with the blazing lights and Montana diamonds. Nevertheless, price notwithstanding, the problem of from whom you will select always comes back to this: How correct is the design of the accessory; how well is it made; how much will it cost to keep it in service; is it reliable; and how long will it last? In brief, how good is it as an investment?

When you are spending somebody else's money, you should be particularly careful to spend it wisely.

The Engineer in Public Service

"IF THE engineer has not been appreciated as much as some other classes of men it is because his service to humanity has not been the highest," said Dexter S. Kimball recently in the course of a speech before the student members of the American Society of Mechanical Engineers. He went on to say that the men who render the greatest service to any nation are those who mold its ideals, and that engineers must do something in this line before they can achieve real public recognition. "I have every confidence," he concluded, "that the engineer will rise to this opportunity, and there are many signs that these ideals are stirring in the minds of forward-looking engineers. It is with no small gratification that we all see the elevation of our past-president, James Hartness, to the gubernatorial chair of his own state, and see Mr. Hoover, an engineer by training and experience, a member of the Cabinet of the new Administration. These are pioneer workers in a field where the lawyer and the politician have long reigned supreme, and their stewardship will be watched by all engineers and others with great interest. It is an auspicious beginning that should hearten all who believe in the application of scientific methods to all problems of human existence."

Much has been said and more has been written lately about the need of public appreciation of engineers, but the public as a whole is never greatly impressed by arguments. The entrance into the limelight of Herbert Hoover and James Hartness is just what is needed to start the ball rolling and to secure general recognition for the engineering profession. It should serve also as an inspiration to other engineers whose modesty, perhaps, has been holding them back.

Tests and Tests

ONCE upon a time, as the fairy books say (only this is no fairy tale), an engineer employed by a well-known stoker company made an acceptance test on an installation of stokers. It was a forty-eight-hour test, and the engineer followed the usual custom of having on hand a plentiful supply of cigars, which were systematically distributed among the operating force.

On the morning of the second day of the test it became quite evident that the figures would show the guaranteed evaporation by a very narrow margin, if at all. During the forenoon the "Havanas" were even more plentiful than before, and after the "Chief" had been tendered and accepted a bountiful and properly lubricated lunch, our stoker-engineer friend, on returning to the plant, produced a neatly wrapped package and holding it aloft spoke in this wise: "Now, boys, you have worked hard, and pulled together in great shape, and we might as well enjoy the last few hours of the test as much as we can, so here goes for a shooting match. I will put this box of cigars over here (indicating a bench at one end of the boiler room) and we will toe the mark over here (indicating a spot at the other end), and the man who scores the most times out of ten wins. Here goes for the first shot." With that, he picked up a generous lump of coal and let fly, missing the box by a narrow margin. His example was followed by all present, and in due course the cigars were awarded to one of the firemen who had made the best record. Apparently, no one noticed that the coal used as missiles had been taken from the pile of unweighed fuel and that the target had been (accidentally, of course) placed very close to the pile of weighed coal ready for firing, so that the total "pounds combustible" was increased by an appreciable but unrecorded amount.

This incident might be multiplied almost indefinitely, with variations, to illustrate the length to which some will go in securing and holding business. A particularly "snappy" set of valve cams and hollow piston rod for the "shop test" of an engine; an iron washer surreptitiously placed inside the case of a wattmeter; over-generous "donations" to pet charities, or "courtesies" extended to individuals in the way of entertainment, traveling expenses, etc.; all are familiar "tricks of the trade," happily, let us hope, fallen into ill repute and no longer existent.

A questionable test or a biased report is worse than none and a dangerous thing for all concerned. Well might the engineering profession say in the words of the poet:

> Earth bears no balsam for mistakes,
> ..... But Thou, Oh Lord,
> Be merciful to me, a fool.

CORRESPONDENCE

Running a Vacuum Heating System Condensing

On page 399 of the March 8 issue of *Power* A. C. Waldron asks a few questions concerning my article relating to vacuum heating systems, which appeared in the Feb. 8 issue. In the first place no vacuum-heating system can be operated condensing with an open heater in the line.

I was not foolish enough to leave a drain pipe on a closed heater open with the end of the pipe discharging below the surface level of the water in a sump well, such as Mr. Waldron said caused trouble by drawing the oil out of the sump, up through the heating system, back to the return pipe to the vacuum pump and then discharging it to the receiver and boiler-feed pump to be fed into the boiler. Some circuit for the oil to travel before signs of trouble showed up!

I did not wait to pump out the sump before I put check valves on the drips; I also provided drains where they would drain. No vacuum breakers are needed on a vacuum heating system if any heating is expected, whether it is run condensing or not. If the heater is on a level with the engine or above it, the exhaust will force the water of condensation into the heating system or out through the exhaust head when running high pressure. It will not stay in the heater long enough to accumulate, as Mr. Waldron states, unless a heater tube is leaking badly.

Anyone who would stop an engine that had been exhausting into a vacuum-heating system without closing the stop valve betweeen the engine and the heating system would have little idea of how the system should be operated. On all such heating plants, when the engine is stopped, live steam is used, and the engine is then exhausting to the atmosphere and the live steam will also escape to the atmosphere if the stop valve is not closed.

Closed heaters will fill with water, on back-pressure heating systems, or when exhausting to the atmosphere, if the drain pipes become obstructed. As far as oil is concerned, I have seen more oil in boilers where back-pressure gravity-return-heating systems were used than on any other systems. If heating systems are properly installed and cared for, there should be no oil in the boilers.

A closed feed-water heater would not do much feed-water heating if the heater was full of water on the exhaust-steam side of the tubes. A hotwell thermometer on the feed pipe to the boilers would certainly show something wrong. With the water in the heater stirred up by the exhaust steam pumping into it, and a vacuum pulling, the water would be carried through the system to the drain pipes and back to the pump. It is easy to drain a system where there is a vacuum if the drains are properly located.

It is true that many engines nave been wrecked by water getting into the cylinders, and open heaters have been burst by overweighting the back-pressure valve, thus putting an over-pressure on the heater, but there is no back pressure on a condensing engine.

A few years ago three 350-hp. engines, all in the same plant, had their cylinder heads knocked off, due to water, one right after another, caused by a rattled engineer. Had the plant been operating a vacuum-heating system, this could not have happened, because the vacuum would have kept the pipe clear of water, and warning would have been given at the pump by its excessive labor in handling the water.

You cannot pull water out of the bottom of a heater that is set below the engine, by a vacuum on the exhaust pipe connected at the top. To do so the pipe would have to extend into the water. Water gets into an engine cylinder and wrecks it because a compound engine running on light load may have a vacuum in the receiver which causes the low-pressure cylinder to act as a pump. Adding this to the vacuum in the jet condenser, which may be running at flood supply or "hung up" and not discharging the water entering it, the inlet-water supply-pipe valve being wide open above the water, it will allow the water to rise in the condenser and pass to the engine cylinder, which causes the wreck. This could not happen on a vacuum-heating system.

When a vacuum-heating system is run properly, there is very little water used above that contained in the steam, because there is no condensing chamber on the return pipe or vacuum pump, only a $\frac{3}{8}$- or $\frac{1}{2}$-in. spray jet for condensing the small amount of vapor that may come back with the air and condensate from the system. This jet would have to be left open over night with the pump stopped to permit enough water to pass up through the return pipe, through the thermograde radiator return valves, flood the radiators up the risers to the exhaust-supply main and flood this main back to the engine room and heater. Before any damage could be caused by pulling the water into the engine, all this would have to be done with a $\frac{3}{8}$- or $\frac{1}{2}$-in. city water valve and the exhaust steam from the engine.

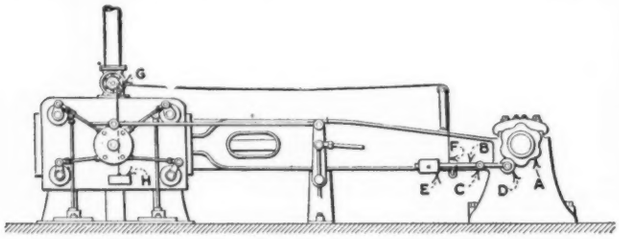
If the engine was running water hammer would burst the radiators long before any water could enter the exhaust supply main.

R. A. CULTRA.

Cambridge, Mass.

A Proposed Home-Made Engine Stop

The engine stop illustrated herewith has never been put to practical use and I am not sure that it will work, but on the face of it it looks as if it would. Doubtless considerable experimenting would be necessary before the scalloped wheel *A* was fashioned with the right



DETAILS OF THE HOME-MADE ENGINE STOP

number of humps to take care of an engine operating at a certain speed.

It will be assumed that the wheel *A* is secured to the engine shaft. A weight arm *B* is pivoted at *C* and carries a roller *D* at one end and a weight *E* at the other. To the lever *B* is attached a cord *F* which is run to a pawl that engages with a sprocket wheel attached to a sheave wheel on the valve stem of the throttle valve of the engine. A weight suspended from a cord that is wound around the sheave wheel is to close the throttle valve when the pawl is released.

The idea is that as the wheel *A* revolves with the engine shaft, the roller *D* will ride over the uneven surfaces of the wheel, thus giving the lever *B* an up-and-down motion, but not sufficient to detach the pawl *G* that engages the ratchet wheel on the throttle-valve stem. If, however, the engine speed increases above a certain predetermined point, the roller *D* will not ride evenly over the wheel *A*, but will bounce with sufficient force to release the pawl, and the weight *H*, corded to the sheave wheel on the throttle-valve stem, will close the valve.

New York City. J. REDMOND.

Design of Hog Fuel Furnace

In answer to Henry D. Jackson's inquiry in the Feb. 22 issue of *Power* regarding the design of a hog fuel furnace, the grate size is stated as being 9 x 6 ft., page 989 of the Dec. 21, 1920, issue. This furnace never gave any bother from smoking. As to the distance from the bridge wall to the boiler shell, I have tried a 20-in. and also a 24-in. space, but find that the 18-in. space gives the best results with the kind of fuel we are using.

Regarding the grate area to the boiler heating surface I find that the required grate surface depends a good deal on the kind of fuel used. In my case we have a large grate area, as the logs are wet and are pulled directly into the mill from a hot pond and are sometimes only partly thawed out. A good many are hemlock and they make a very poor fuel. Having a large grate area allows the fuel to pile up with time for it to dry out.

On the other hand, with dry or partly dry fuel such large grate area is not necessary as the wood readily ignites upon entering the furnace. The kind of fuel used has much to do with the space required between the bridge wall and the boiler shell and the opening in the throat. Our boilers are doing fine work with a setting designed as shown in the December 21 issue and are working above their rated capacity during the winter months. The company is building another plant and putting in practically the same settings with the exception of a slight difference in the filling back of the bridge wall, and that is owing to the fact that part of the fuel will be dry.

Regarding Mr. Jackson's question as to the greatest distance between the boiler and grates where economical results have been found, it would be difficult to give any figures or description of a setting without knowing what kind of fuel is to be used and also about the draft, whether forced or natural, and whether it is a dutch oven or plain setting. I think it is nearly impossible to give correct figures for building a dutch-oven setting to burn wood fuel without knowing the conditions and kind of fuel to be burned. G. L. BALDWIN.

Millsite, Vt.

What Caused This Pipe Corrosion?

I wonder if any of the readers of *Power* can shed light upon a problem that has caused considerable expense and inconvenience. Our plant is heated by horizontal overhead coils, using exhaust steam while the plant is in operation and live steam over Sundays and holidays.

After about twelve years of use, the pipes in the coils were found to be corroded on the inside in a

SHOWING CORROSION OF HEATING PIPE ALONG THE TOP

narrow strip along the top of the pipe. The illustration shows a piece of one of the pipes which had not been completely eaten through except at the threaded end. The sides and bottom of the pipe are as sound as the day it was installed.

What caused this condition and how can it be overcome? The trouble was general throughout the plant, and the greater part of the equipment had to be changed. The heating system is fitted with steam traps and has a vacuum return. D. R. FORBES.

Rockford, Ill.

Relief Valve in Feed Line

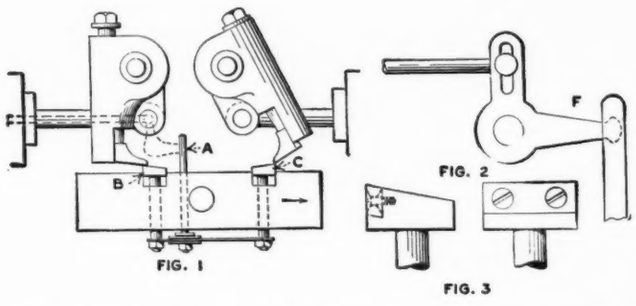
That a check valve may become deranged and prevent feed water from entering a boiler was shown in a recent issue of *Power*. This may bring about a dangerous condition if a closed feed-water heater is on the line, as there is the danger of bursting the coil due to excessive pressure. Besides the expense of putting in a new coil or repairing the old one, the boilers would probably have to be fed with cold water while the heater was undergoing repairs, which might cause the boilers to leak.

I believe that operating a steam boiler without a relief valve on the feed line between the pump and the boiler-check valve is not safe. A large boiler-feed pump can develop a dangerous pressure if there is any obstruction to prevent the water from going through the feed line to the boiler; and if the coil in the closed heater should burst, it would cost more to replace it than the price of many relief valves.

New York City. PATRICK MOLLOY.

Some Greene Engine Improvements

In the plant of which I have charge there is an improved tandem-compound Greene engine operating with a widely varying load, the engine having all it could do at times or else running with no load at all. With a heavy load the receiver pressure would drop and the engine would slow down. When the load went off, the receiver pressure would run up until the relief valve blew, and the engine would then speed up. I became convinced that the trouble was due to the incorrect design of the cutoff mechanism and I learned that other engineers had experienced the same trouble with this type of engine. I decided that the high-pressure cylinder tappets did not move as quickly as the low-pressure cylinder tappets. That is, when the governor moved to give a longer cutoff, the low-pressure tappets moved faster than the high-pressure tappets, thus causing the receiver pressure to drop. Again, when the governor moved to shorten the cutoff, the low-pressure tappets moved faster and the receiver pressure built up.



FIGS. 1 TO 3. CHANGES MADE ON VALVE CONTROL GEAR

Fig. 1 shows the construction of the tappet gear. The rod *A* which raises or lowers the tappets to change the point of cutoff, is operated by a bell crank, which in turn is connected to the governor. Having a spare bell crank, I had the end to which the governor rod is attached slotted, so that the leverage could be changed, as shown in Fig. 2. After several trials a point was found where the receiver pressure remained practically constant for moderate changes of load. When the load became very much heavier, there was an increase in the receiver pressure, thus helping to keep the engine up to speed. This ended my troubles with this engine on that score.

The tappets *B* and *C* wear round, so that at light loads they miss and do not open the valves. It is an item of considerable expense to renew them. I overcame this difficulty by having the face of the tappets milled out as shown in Fig. 3, and inserting a hardened steel plate, which can be reversed and also renewed at slight expense.

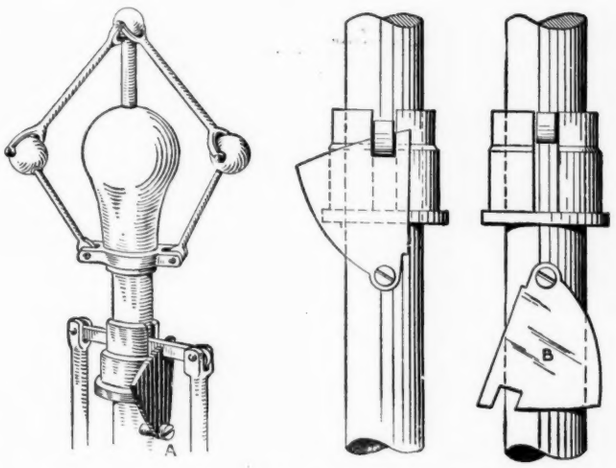


FIG. 4. THE HOME-MADE GOVERNOR SAFETY STOP

Our engines are insured against flywheel accident. The stop-motion pin on some Greene engine governors is a slotted ring, the ring being turned after the engine is up to speed so that if the governor belt should break, the governor could come down and operate the safety stop. The insurance company required a stop pin that would act automatically when the engine reached a certain speed, so that there would be no chance to forget to turn the stop ring. Fig. 4 illustrates the device that I used to meet the insurance requirements. The piece *A* is so shaped that when the governor rises it drops to position *B*.

EDWIN W. CREED.

South Braintree, Mass.

Volatility of Lubricating Oils

In looking over a recent issue of *Power* an extract from Bulletin No. 191, Bureau of Mines, on the "Relation of Gravity to Volatility of Gasoline" caught my eye, and after reading it I realized that heretofore I had seen nothing of engineering value on volatility in its relation to the operation of equipment.

It has never yet been mentioned in my hearing in laboratory, power house or engine room that the evaporation of an oil is variable and relative to a greater or less degree to the various physical constants determined by test. Engineers are aware of physical tests, such as using a piece of heated iron in testing cylinder oil, etc., but very generally they are unaware of the relations existing between the various physical constants supplied them on the purchase of the lubricant. It was given me at one time to determine this relation in a general way, and although I am not able to present the actual test results the principles found to exist are submitted for what they are worth, as follows:

There is a marked difference in the percentage of evaporation loss of oils of different bases at the same temperature.

The oil of characteristic higher gravity has the higher percentage evaporation loss.

In straight-run oils of the same crude the evaporation loss varies inversely as the specific gravity.

In straight-run oils of the same base the loss varies inversely as the viscosity.

In blended oils the evaporation loss depends chiefly on the gravity and viscosity of the lightest oil entering into the blend.

The percentage loss is usually greater in a blended oil than in a straight-run oil of the same gravity and viscosity.

The flash point and fire point in oils of the same base vary indirectly with the evaporation loss.

The evaporation is relatively high for a certain initial period, decreasing rapidly at first and then more slowly, until the loss per unit of time becomes very small and practically constant.

The loss obtained is greatly dependent on the ratio of the amount of oil surface exposed to direct evaporation to the volume of oil being tested. This makes uniform testing conditions imperative.

Blended oils allow comparatively rapid evaporation of the lighter fractions, leaving the fractions of very high viscosity which were originally used to bring the mixture up in gravity. This was further substantiated by fractionation tests.

The tests from which the foregoing conclusions are deducted were made in small brass containers of uniform size and shape, which were heated in an automatically controlled oven at a fixed temperature and so constructed as to give uniform heating conditions.

The significance of the foregoing remarks may be brought out in a few examples. Not considering first costs, we would conclude that a good turbine oil of a given viscosity should have the least tendency to become heavy with use; that is, the evaporation loss should be small to cut down the renewal of the oil. It is apparent that a pure straight-run oil of relatively low gravity and high flash point would be preferable, the viscosity, however, being the initial or basic consideration.

In a gas engine the straight-run oil of characteristic lower flash point and high evaporation loss will probably prove most satisfactory, because of the lack of tendency to gum on the combustion-chamber walls and form carbon deposits.

In sight-feed lubrication a good blended oil would be satisfactory, as the oil is not generally reused and does not require special evaporative qualities.

Cylinder oils should have low evaporation to give longer life and greater economy.

It is to be remembered that in all the foregoing examples the cost of oil renewal and the quantity actually consumed will have considerable influence in the selection of an oil, but it is not an invariable rule that the cheapest oil that will "get by" is the best oil to use.

Although the gravity expressed in "degrees Baumé" is entirely logical and satisfactory to the manufacturers, it appears to me that it would be more satisfactory to use "specific gravity" in expressing the density relation. The latter term is fundamental, easily expressed, bears a direct relation to the density, and changes directly with change of density, while the "degrees Baumé" changes inversely with density so that a term expressing high gravity may refer to higher degrees Baumé and give the wrong impression.

Much more could be written on this subject, including influence of specific heats on evaporation losses, which would be of value in the selection of the turbine oil particularly, but that is not the purpose of this short résumé. It would be interesting to hear from engineers who have had the opportunity to investigate the actual behavior of oils in operation to check the practical results with the foregoing test results conducted on small samples.

H. R. SMITH.

Bound Brook, N. J.

Efficient Burning of Fuel Oil

The steam plant is at best an expensive proposition. In a well-regulated hand-fired steam plant one would expect to find at least a coal scale and a water meter and perhaps a CO_2 machine. When a change is made from coal to oil, why are not fuel-oil meters and recording thermometers installed, so that the operators may know positively the temperature of the oil in the storage tanks and also the amount of fuel consumed during any one hour?

Why do not those responsible for the change in fuel go a little farther and do a first-class job by installing apparatus, which should include the necessary instruments, in addition to a couple of pumps, heaters and burners that go to make up the equipment of the usual installation?

If the man in charge of the power plant wants to continue burning fuel oil, he must strive to make it produce a kilowatt at less cost than with coal. In the large plant he cannot show as much labor saving by oil as he might wish, therefore the little B.t.u.'s must be made to earn their salt, as it were.

One correspondent recommends that the oil pressure be from 100 to 115 lb. It will depend altogether on the burner as to whether even 50 lb. is to be maintained on the line. A temperature of 170 to 180 deg. F. is good, depending on the degree Baumé.

Perhaps a good suggestion on the economical burning of fuel oil is to have a pressure gage on both steam and oil connections to the burner below the valve; that is, between the burner and its control. Then, if it is necessary to throttle the oil, the steam can also be throttled to the right amount. If samples of gas are analyzed, it will, after a time, be possible to know just what each gage should record. For instance, certain makes of steam burners will operate successfully with oil from 10 to 50 lb. pressure and at the same time the steam should be 60 to 150 lb. Should the load momentarily drop, the oil and steam would be throttled to, say, 40 lb. for the oil and 120 lb. for the steam. Perhaps the next drop would be, oil 20 lb. and steam 80 lb. The same ratio does not obtain throughout the cycle. The pressure of steam may be five times the pressure of oil at low pressure, but at maximum it may be only 3 to 1.

I find that it is quite essential to make experiments along the lines mentioned to get the best results. I suggest that the nice-looking vapory haze from an oil-burning plant is costing someone good money. The CO_2 generally shows up better if a light-brown color is present.

C. W. PETERS.

New York City.

INQUIRIES OF GENERAL INTEREST

Loss of Draft Through Boiler—What would be a fair allowance for loss of draft through a water-tube boiler? R. G.

The draft resistance varies largely with the design of the boiler and the percentage of capacity at which the boiler is operated. In a well-designed water-tube boiler the loss is about 0.25 in. of water when the boiler is operated at rating, 0.4 in. at 150 per cent of rating, and 0.65 in. at 200 per cent of rating.

Circumferential Pitch of Staybolts—In measuring the pitch of a circular row of staybolts in the furnace sheet of a vertical boiler, would the pitch distance be taken as the straight-line length of chord from center to center of staybolts, or would it be the distance measured along the curvature with a flexible rule? L. L. S.

The spacing is known as the circumferential pitch and would be the measure from center to center of staybolt holes taken circumferentially, as obtained by a flexible rule held close to the curved surface of the firebox sheet.

Negative Lead and Negative Lap—What is meant by negative lead and negative lap of a valve? H. C.

Lead is the distance a steam valve has the port uncovered at the beginning of the stroke of the piston, and negative lead is the distance the valve overlaps the edge of the port at the beginning of the stroke of the piston. The lap of a valve is the distance the valve overlaps the port when the valve is at the middle of its travel, and negative lap is the distance the port is uncovered when the valve is in central position.

Cushioning on Exhaust of Duplex Pump—What prevents a duplex steam pump from striking at the ends of the stroke? W. R.

The passage for the escape of exhaust steam from the cylinder is covered by the piston before completion of the stroke, and exhaust steam then remaining in the end of the cylinder and steam passage is compressed by further movement of the piston and acts like a cushion in bringing the piston to rest before it reaches a position to strike the end of the cylinder.

Conditions Indicated by Percentage of CO_2—What is the theoretical maximum percentage of CO_2 in flue gases, and what does a low percentage indicate? C. S.

The CO_2 percentage is affected by the character of the fuel. The more hydrogen in the fuel the less the CO_2 in the flue gases. If it consisted entirely of hydrogen, there would be no CO_2, and if it were all carbon the maximum would be 21 per cent CO_2. Low CO_2 may be caused by excess air, insufficient air resulting in high CO or improper mixture of the air and gases, but more generally low CO_2 is the result of a surplus of air and the difference between the CO_2 percentages in the last and first passes indicates the air leakage in the setting.

Friction of Bearing Directly as Total Pressure—Does increasing the length of a bearing add to the power required to overcome friction? W. E. G.

For a given lubrication or coefficient of friction, the frictional resistance is directly as the total pressure and independent of the area over which the pressure is distributed. Consequently, increasing the length of bearing with the same lubrication of the bearing surfaces will not add to the power required to overcome friction. On the other hand, increasing the length reduces the pressure per square inch, thereby permitting of better lubrication, and when that is the case the power required to overcome friction is reduced.

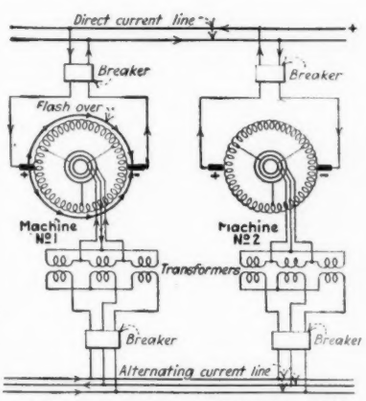
Cylinder Ratio of Compound Engine—What should be the ratio of capacity of the cylinders of a compound engine using the steam at an initial pressure of 135 lb. absolute per square inch, expanding to a terminal pressure of 10 lb. absolute in the low-pressure cylinder, with cutoff at 30 per cent length of stroke in the high-pressure cylinder? W. R. T.

Neglecting clearance, the initial volume of steam admitted up to cutoff in the high-pressure cylinder would be $\frac{10}{135}$ of its volume after completion of expansion in the low-pressure cylinder, and as the initial volume is to be 30 per cent of the volume of the high-pressure cylinder, the ratio of capacities of the cylinders should be

$$\frac{30}{100} \div \frac{10}{135} \text{ or } \frac{135 \times 30}{10 \times 100} = 4.05$$

Reversed Polarity of Converter Caused by Flash-over.—Two 700-kw. synchronous converters were operating in parallel, when one flashed over at the commutator, tripping both its alternating and direct-current breakers, and the direct-current breaker on the other machine. The machine that did not flash over was then found to have reversed its polarity. What is the reason? J. W.

Referring to the figure, when machine No. 1 flashed over, and before the breakers could open the circuit, the energy consumed in the flash had to be supplied in part from the alternating-current supply through the machine itself, and in part from the direct-current side of machine No. 2, as indicated by the arrowheads in the diagram. The latter portion of the energy should have come directly through machine No. 2 from the alternating-current circuit; but the reactance of the transformer held it back long enough to cause the converter to slow down momentarily, and give up some of its energy of rotation to make up the deficiency in the input. This caused the machine to "slip a pole," or drop back one-half cycle, thus changing its polarity.



POWER FLOW BETWEEN CONVERTERS DURING FLASH-OVER

Interpretations of the A. S. M. E. Boiler Code

REQUESTS for interpretations of the Boiler Code are acted upon by the Boiler Code Committee, their formulated replies being submitted to the Council of the American Society of Mechanical Engineers. The inquiries and replies are published from time to time in *Power*, with such explanatory comments and illustrations as seem advisable for a clear understanding of the interpretations on the part of engineers in general. The last group of interpretations published in *Power* was in the issue of March 1, 1921.

Case No. 324—Inquiry: In the formation of the header element of a water-tube boiler to operate at 500 lb. pressure, with a tubular header 2 in. O.D., is it necessary that the ligament between two openings, where 1⅛-in. cross-tubes are inserted on 1½-in. pitch, shall be designed under the requirements of Par. 192?

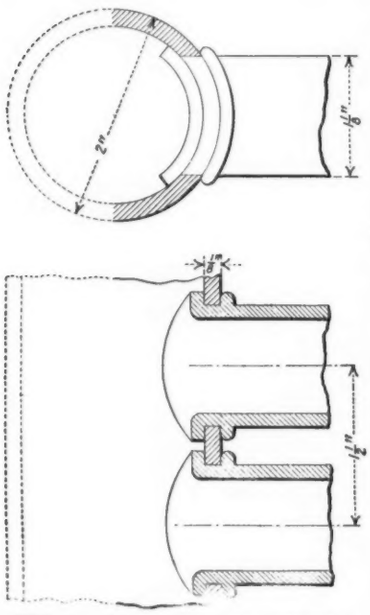


FIG. 1. CASE NO. 324—SPECIAL HEADER CONSTRUCTION

Reply: It is the opinion of the committee that while the strength of the construction may be calculated by the ordinary formula for cylinders, there are elements in the particular design which may result in the ability to carry higher pressures than would be allowed by the ordinary formula. The committee therefore recommends that a test be made as provided for in Par. 247 of the Code. It further recommends that in making the test the pressure that will cause the material to be stressed to the yield point be determined.

Par. 192 provides formulas for ascertaining the efficiency of ligaments in shells or drums which are presumably of large diameter as compared with the tube holes. For the special conditions described, however, in which the header is less than twice the dameter of the tubes, which are to be die-formed hot in position (see Fig. 1), it is obviously to the manufacturer's advantage, as recommended by the committee, to follow the procedure outlined in Par. 247, which provides that "where it is impossible to calculate with a reasonable degree of accuracy the strength of a boiler structure or any part thereof, a full-sized sample shall be built by the manufacturer and tested to destruction in the presence of the Boiler Code Committee or one or more representatives of the Boiler Code Committee appointed to witness such test."

Case No. 328—Inquiry: Is it necessary, in the manufacture of boiler and superheater headers of open-hearth steel pipe, that the tensile strength be calculated on the basis of 55,000 lb., or is steel of lower tensile strength allowable in material of this form as permitted under Par. 28c of the Boiler Plate Steel Specifications?

Reply: If the material in the header conforms to a steel specification other than steel-plate specification and shows a lower tensile strength than 55,000 lb. per sq.in., it is the opinion of the committee that it is permissible to calculate the header design on the basis of this lower value the same as is permitted for steel-plate material as indicated in Par. 28c. See also Case No. 218.

Par. 28c. of the Code, reads as follows: "If desired, steel of lower tensile strength than the above (55,000 to 65,000 lb. per sq.in.) may be used in an entire boiler or part thereof, the desired tensile limits to be specified, having a range of 10,000 lb. per sq.in. for both flange and firebox, the steel to conform in all respects to the other corresponding requirements herein specified, and to be stamped with the minimum tensile strength of the stipulated range."

In Case 218 the question is asked: "For material to be used as headers and manifolds of superheaters, does that of open-hearth, extra-heavy lap-welded steel pipe meet the requirements, etc.?" The reply is: "Under the requirements of Par. 9 and 11, headers and manifolds of superheaters must be constructed from material which, in its initial form of plate or skelp, conforms to one or the other of the specfications given in the Boiler Code for wrought steel, or they may be constructed of cast steel of the Class B grade" (for which physical requirements are specified). The fundamental requirements for this and similar cases will be found in Par. 11 of the Code, whch reads as follows: "Pressure parts of superheaters separately fired or attached to stationary boilers, unless of the locomotive type, shall be of wrought steel, or cast steel of Class B grade, as designated in the Specifications for Steel Castings."

Case No. 329 (Reopened)—Inquiry: What tensile strength shall be used for the calculation of the maximum allowable working pressure of pressure parts formed of steel castings of Class B grade or of seamless steel tubing?

Reply: It is the opinion of the committee that the tensile strength used in the calculation of pressure parts formed of steel castings of Class B grade or of seamless steel tubing shall be the minimum tensile strength determined from tests made on the test specimens located and taken as given in Par. 88 of the Code. While the Code contains no specific statement as to the tensile strength of the material used in seamless tubing, it is the opinion of the committee that 50,000 lb. could be used as a basis for calculating the safe working pressure.

Case No. 331—Inquiry: Is it permissible, under Par. 311a of the Boiler Code, to use in the blowoff connection a valve and a cock formed in a single body casting, instead of two separate valves or a valve and a cock as specified in that paragraph?

Reply: It is the opinion of the committee that the use of two valves, or a valve and a cock, combined in one body, does not meet the requirements of Par. 311a of the Boiler Code.

Par. 311a provides that "on all boilers, except those used for traction and portable purposes, when the maximum allowable working pressure exceeds 125 lb. per sq.in., each bottom blowoff pipe shall have two valves, or a valve and a cock, and such valves or valve and cock shall be extra-heavy," etc.

Case No. 332—Inquiry: Is it permissible under the requirements of the Boiler Code to attach a nozzle outlet to a pipe-header manifold by inserting the nozzle through a hole in the header and peening the edges over inside the header, as shown in Fig. 2, the nozzle being autogenously welded to the header on the outside for steam tightness?

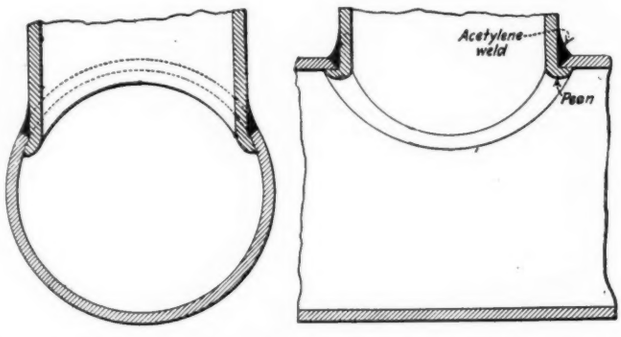


FIG. 2. CASE NO. 332—DESIGN FOR ATTACHING NOZZLE OUTLET TO PIPE HEADER NOT APPROVED

Reply: It is the opinion of the committee that this construction will not meet the requirements of Par. 186 as peening over of the inserted edges of the nozzle will not afford greater strength to withstand the steam pressure on the cross-sectional area of the nozzle than flaring as specified in Case No. 235.

Par. 186 provides that "autogenous welding may be used in boilers in cases where the strain is carried by other construction which conforms to the requirements of the Code, and where the

safety of the structure is not dependent upon the strength of the weld."

In Case 235 the committee reported adversely on an inquiry regarding the formation of "an outlet nozzle on the steel-pipe header of a boiler by inserting a nipple through a hole bored in the side of the pipe header for a driving fit, and flaring the interior projecting end, and then subsequently welding to the header around its outside circumference for steam-tightness, the metal in the pipe header being of a lesser thickness than that required to make an expanded joint."

Case No. 333—Inquiry: (a) Where a steam nozzle or safety-valve nozzle is placed upon a boiler drum in which the shell is made thicker than that required for giving a factor of safety of 5, do the requirements of Par. 260 and 261 apply, which specify that the strength of the reinforcing rings shall be at least equal to the tensile strength of the maximum amount of the shell plate removed by the opening and the rivet holes for the reinforcement, and that the strength of the rivets in shear on each side of the reinforcement shall equal the tensile strength of the maximum amount of the shell plate removed by the opening?

(b) Does Par. 325 respecting allowable shearing and crushing stress on rivets used for attaching lugs or brackets apply to other than h.r.t. boilers for constructions where the weight is more evenly divided between the lugs than in the case of h.r.t. boilers?

Reply: (a) The requirements in Par. 260 and 261 are based on the use of a shell having a thickness corresponding to a factor of safety of 5 at the seams, or weakest part of the shell. Where the thickness of the shell is greater than necessary to give a factor of safety of 5, the openings through the shell, to meet the requirements of Par. 260 and 261, need not be reinforced to any greater amount than that required for such a shell.

Aside from the requirements in Par. 260 and 261, the flange of the nozzle should be made substantial enough to withstand cross-strains to which it may be subjected through expansive strains of the piping, etc.

(b) Par. 325 applies to all types of boilers irrespective of the number of lugs employed.

Case No. 334—Inquiry: Is it permissible, under the requirements of Par. 332, to apply the A. S. M. E. Code boiler stamp to a boiler whose construction cannot be completed in the shop so as to subject the drum or any of its parts to hydrostatic test? Such a test would be practical only after the boiler has been erected in the field.

Reply: It is the opinion of the committee that those boilers which cannot be completed and hydrostatically tested in the shop may have the stamping applied before shipment, final certification to be made after hydrostatic test is made in the field.

The second part of Par. 332 provides that "after obtaining the stamp to be used when boilers are to be constructed to conform with the A. S. M. E. Boiler Code, a state inspector, municipal inspector, or an inspector employed regularly by an insurance company which is authorized to do a boiler-insurance business in the state in which the boiler is built, and in the state in which it is to be used, if known, is to be notified that an inspection is to be made, and he shall inspect such boilers during construction and after completion. At least two inspections shall be made, one before reaming rivet holes and one at the hydrostatic test. In stamping the boiler after completion, if built in compliance with the Code, the builder shall stamp the boiler in the presence of the inspectors, after the hydrostatic test, with the A.S.M.E. Code stamp, the builder's name and the serial number of the manufacturer."

Although it may naturally be assumed that the hydrostatic test will be made in the shops where the boiler was built, a careful scrutiny of Par. 332 does not disclose any definite statement that makes this obligatory.

Case No. 336—Inquiry: An interpretation is requested of the term, "or other opening," in Par. 260 and 261 of the Boiler Code. Does it apply to openings cut for steel nozzles and boiler flanges?

Reply: It is the opinion of the committee that the term, "or other opening," applies to openings cut for steel nozzles and boiler flanges, over 3 in. pipe size.

Par. 260 provides that "manhole frames on shells or drums when used shall have the proper curvature, and on boilers over 48 in. in diameter shall be riveted to the shell or drum with two rows of rivets. . . . The strength of manhole frame and reinforcing rings shall be at least equal to the tensile strength of the maximum amount of the shell plate removed by the opening and rivet holes for the reinforcement on any line parallel to the longitudinal axis of the shell through the manhole or other opening."

Par. 261 provides that the strength of the rivets in shear on each side of a manhole frame or reinforcing ring shall be at least equal to the tensile strength of the maximum amount of the shell plate removed by the opening and rivet holes for the reinforcement on any line parallel to the longitudinal axis of the shell, through the manhole, or other opening."

Case No. 338—Inquiry: Is it necessary in the construction of a 54-in. drum of a vertical water-tube boiler, which is formed of 1 1/16-in. plate with 3 3/32-in. tube holes, giving a ligament efficiency of 47.3 per cent, to use a butt strap 3/4 in. thick as indicated in Table I of the Boiler Code? It is evident that the shell above the ligaments is much stronger than necessary for the desired working pressure of 225 lb. per sq.in., and that 23/32 in. thickness of shell is all that is necessary outside of the ligaments.

Reply: It is the opinion of the committee that in the design of a joint for such a drum where the shell thickness is purposely made thicker than necessary for the working pressure in order to increase the ligament efficiency, the butt straps and riveting need not be proportioned for a greater strength than that necessary to carry the working pressure for which the drum is designed.

Case No. 339—Inquiry: Will an internal feed pipe formed of a main feed pipe with numerous small short nipples tapped into one side and with elbows at either end bushed down to similar small nipples, as shown in Fig. 3, meet the requirement of Par. 314 of the Boiler Code? This arrangement is made to force a certain amount of water to flow through the nipples instead of all through two nozzles.

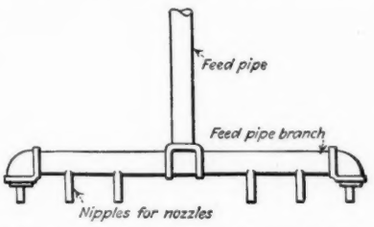


FIG. 3. CASE NO. 339—DESIGN FOR FEED PIPE HEADER NOT APPROVED

Reply: It is the opinion of the committee that the construction proposed does not meet the intent of this requirement, which specifies open ends of the pipe in order that incrustation may not under any circumstances cause stoppage.

Par. 314 provides that "the feed pipe of a boiler shall have an open end or ends inside of the boiler." While the arrangement shown in the illustration is rejected by the committee as contrary to the evident intent of the paragraph quoted, it is undersood that there is no objection to the nipples as shown, or having holes bored in the cross-pipe or header to provide a distributing effect, provided the ends of the header or elongated tee are not obstructed, so that in case the small apertures provided for the purpose of distribution are clogged by incrustation, ample cross-sectional area for steam delivery will be provided by the open ends of the pipe.

Case No. 340—Inquiry: Is it permissible under the requirements of the A. S. M. E. Boiler Code to construct a 66-in. h.r.t. boiler for hot-water heating, to operate at pressures exceeding 50 lb., in which (a) handholes only are provided for cleaning and inspection, or (b) with manhole below the tubes only and tubes filling the entire upper space of the shell, there being no steam space required?

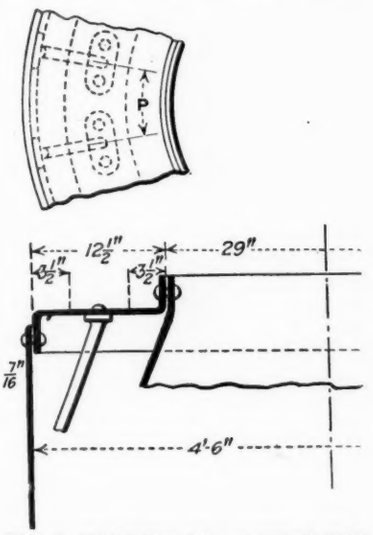


FIG. 4. CASE NO. 341—DESIGN FOR TOP HEAD OF VERTICAL SUBMERGED-TUBE BOILER

Reply: In the opinion of the committee, this case is fully covered by Par. 264, and the construction would be in accordance with the Code if sufficient provision were made for adequate inspection.

Par. 264 provides that "all boilers must be provided with suitable manhole or handhole openings, except special types where they are manifestly not needed or used. A manhole shall be located in the front head, below the tubes, of a horizontal return tubular boiler 48 in. or over in diameter. Smaller boilers shall have either a manhole or a handhole below the tubes. There shall be a man-

hole in the upper part of the shell or head of a fire-tube boiler over 40 in. in diameter, except a vertical fire-tube boiler, or except on internally fired boilers not over 48 in. in diameter. The manhole may be placed in the head of the dome. Smaller boilers shall have either a manhole or a handhole above the tubes."

Case No. 341—Inquiry: What is necessary to determine the pitch of the braces to stay an annulus in the top head of a vertical submerged-tube boiler shown in Fig. 4, in which the annular space is 5½ in. wide by 36 in. in inside diameter, and the boiler is to be operated at 100 lb. per sq.in.?

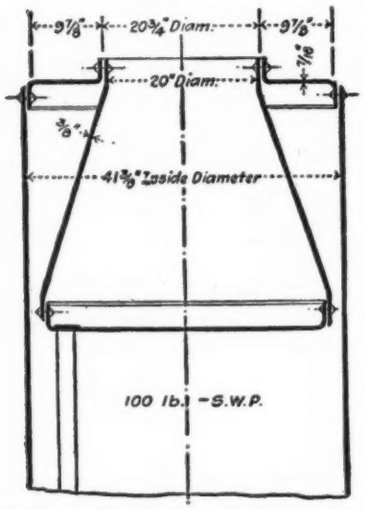


FIG. 5. CASE NO. 308—(REFERENCE IN REPLY TO CASE NO. 341). DESIGN FOR TOP HEAD OF VERTICAL SUBMERGED-TUBE BOILER

Reply: There is no specific rule in the Code applying to such construction. Par. 203a indicates the permissible coefficient *C* for the formula in Par. 199, from which the maximum distance between centers of rivets should be determined. Table V gives the permissible stress for braces which, in conjunction with the total pressure on the annulus (making proper allowance for angularity of the braces), designates the total brace area necessary. See also Case No. 308.

Case 341. In Case 308 the question is asked: "Under what rules in the Boiler Code should the top head of a vertical submerged tube type of fire tube boiler, such as shown in Fig. 5, be calculated to determine whether or not it requires bracing?" The reply is: "There is no rule in the Code specifically applying to such construction. However, in Par. 216 an allowance is made for surfaces located between tubes and shells. It is the opinion of the committee that it would be entirely safe to permit similar allowances in this case; that is, the distance between supported points could be made 3 in. greater than the permissible spacing of staybolts by the corresponding plate thickness and pressure given in Table IV."

In accordance with this ruling it is found, on reference to Table IV, that the head as described, and as shown in the accompanying figure, does not need bracing. In Case 341, however, it is evident that the maximum spacing allowed in Table IV. is exceeded by more than 3 in., and that spacing is therefore necessary. Computation in conformity with Par. 203a and Par. 199 shows that the maximum distance between centers of rivets should be slightly over 8 in., and that 16 rivet holes evenly spaced on a diameter of 41⅜ in. will comply with the requirements of the paragraphs referred to.

To Take Stock of Coal on Hand

Under a specific order from the Secretary of the Interior, the United States Geological Survey is making a nation-wide canvass to determine the state of consumers' stocks. The Survey gathers regularly and makes public each week complete information on the production and movement of coal and on operating conditions at the mines. This is not to be taken as an indication, the Survey says, that coal will be either scarce or abundant, but it is believed the report will make possible a much more reliable answer to the question. For the purposes of this report consumers have been classified as follows: Industrial, retail coal dealers, steel industry, byproduct coke plants, electric power plants, coal-gas plants. All types of consumers are asked to report stocks on hand Jan. 1, 1921, coal received Jan. 1 to March 31, coa consumed Jan. 1 to March 31, and stocks on hand March 31. Consumers also are asked to answer "What should be your normal stock as of March 31?"

Natural gas is being wasted on the Mexican oil fields in tremendous quantities, according to *El Heraldo de Mexico*. It is said that a certain amount of gas is separated from the oil at the wells, carried some distance away and burned, and that it would be possible to extract nearly 16,000,000 gal. of spirit per year from this gas.

The Present State of the Gas Turbine

By H. O. Herzog

At the recent annual meeting of the Society for the Study of Combustive Fuel, a paper was read by Professor Stauber upon the present state of gas turbine construction. Professor Stauber only casually mentioned the various inventions in the field of gas-turbines which, as he said, are in many cases the work of laymen dabbling in engineering science. He chiefly occupied himself with a discussion of the Holzwarth gas turbine, which in his opinion seems to be the only design of practical value. Even in this case he is not sure whether the Holzwarth gas turbine can be marketed successfully. The present conditions are very unfavorable for the introduction of gas turbines. The over-all economy of the plant is of course the most decisive factor.

When comparing the gas turbine with the piston gas engine or the steam turbine, equal conditions should be taken into account, which is often neglected. It has to be considered how the heat is supplied, whether in the shape of gas with or without utilization of byproducts, whether the engine can be easily controlled, what is the average load and whether the generation of gas is in due ratio to the requirements. Assuming an average load of 72 per cent of the full load, the heat consumption would be 19,840 B.t.u. per kw.-hr. for the piston gas engine, 33,700 for the steam turbine, and according to data supplied by Holzwarth, 25,800 for the gas turbine.

When taking the initial cost for the gas turbine on the basis of prices of heat and machines somewhere midway between those of 1914 and the present ones, the costs of heat for the generation of one kilowatt-hour by the piston gas engine, steam turbine and the gas turbine will be at ratios of 7, 12 and 9 respectively, and the total costs per kilowatt-hour at 72 per cent of average load will have ratios of 22.8, 20.7 and 19.5. These figures have only comparative value and alter with the ratio of cost of fuel to initial cost of plant.

There would be no saving at all if the estimate were based on the high price of coal prevailing in some countries, in which case the piston gas engine would have the advantage over the gas turbine, while the same would happen in the case of the steam turbine if coal was secured at an extremely low price or if the prices for machinery were rising. If the gas turbine is to get an assured position in industrial life, it is imperative to produce it cheaply.

All the different types of gas turbines tested up to the present time followed, more or less, the lines of the steam turbine, which works at high speeds of rotation and at comparatively low pressures. The piston gas engine can easily use much higher pressures and therefore causes smaller loses when transforming the energy of the gas into work. A disadvantage of the latter is of course the crank and piston mechanism.

Professor Stauber then alluded to the Humphrey pump, which combines the advantages of the piston gas engines and the turbine. Several inventors have attempted to utilize the drive of the Humphrey pump for turbines without succeeding in overcoming the difficulties in the way. Professor Stauber is, however, of the opinion that a practical solution of the problem of utilizing the water column accelerated by imparting explosions for the gas turbine is quite within the reach of possibility.

In the ensuing discussion Professor Foettinger mentioned that he had arrived at a similar conclusion in the course of his researches with the hydraulic transformer. He believes that the surprisingly high values of efficiency obtained by hydraulic transformers causes the use of water for the transmission of power in gas turbines to appear in a promising light. Of course the phenomena caused by the splashing and the shocks of the water require thorough investigation. Schnell-Munich concurred in this opinion, asserting that he believes he has found a practical way for avoiding splashing and the losses due to shocks.

The primary horsepower installed in Vermont increased from 173,937 in 1914 to 185,107 in 1919, or 6.4 per cent, according to a preliminary report of the Census Bureau of the United States Department of Commerce.

The Recovery of Lubricating Oil*

By Alfred J. Wilson

The apparatus employed in cleaning oil that has become too dirty for further use in an internal-combustion engine may be classed as follows:

(1) Those in which the oil is allowed to settle either with or without warming; (2) those in which settlement and filtration are carried out in a series of chambers; (3) those in which the oil is passed through boiling water heated by means of steam coils or electric heaters, with no chemical after treatment; (4) those which warm, but do not boil the water, and clear the heated oil by chemical means; (5) those in which the oil is passed through a centrifugal cleaner.

The chief claim for class 1 is its great simplicity, consisting, as it does, of a deep cylindrical tank having a fine gauze strainer at the top, through which the dirty oil is poured, and provided with three or more taps at different levels; a sludge outlet at or near the bottom is also fitted. The objections are the length of time required to obtain good results and the relatively large number of these settling tanks needed, as the oil should not be disturbed by drawing off and adding further dirty oil. The remaining types are in general use, each plant modifying a system to meet local conditions. The centrifugal system is in use on ships, but requires refiltering to remove the fine carbon in the oil.

Lubricating oil recovered after use in a Diesel engine generally shows a decrease in specific gravity if the engine has been run on a petroleum-residual fuel oil having a lower specific gravity than what the lubricating oil itself possessed when new. Drippings from the fuel pump find their way into the bedplate of an open-type engine and get mixed up with the lubricating oil, thereby affecting its specific gravity and, incidentally, its flash point also. Worn pistons and liners tend to increase the amount of carbon in suspension, while new pistons or liners contribute an undue amount of mechanical impurities to the oil until a smooth surface has been built up in the cylinder.

Acidity Increases After Use

An increase in acidity after use is noticeable in the filtered oils, and except where chemical means have been employed to neutralize the acid this enhanced acidity remains permanently. The increase in acidity is very marked in the untreated straight hydrocarbon oils, being more than five times that of the original oil in one case and three times in another plant.

The increased acidity feature is particularly interesting, as in some plants where recovered oil is re-used without any attempt at neutralizing the acid, some trouble might be expected with the air compressors in consequence. A considerable proportion of new oil is frequently added to make up loss, thereby reducing the acid value appreciably.

The claim that acidity is detrimental to oil used for purposes other than for air compressors has yet to be proved, and considerable evidence in support of the use of fatty acids for blending with mineral oils has been put forward in a paper given before the Society of Chemical Industry by Messrs. Wells and Southcombe.

If we can assume that lubricating oil knows no fatigue and never wears out, then we must have arrived at the state where it is possible for the owner of a Diesel engine to buy a certain quantity for its use, install an efficient recovery plant and never purchase any more oil other than is required to make up loss by carbonization or cracking on cylinder walls, oil flinging and other leakages.

In order that we may have some basis upon which we can judge whether an oil has suffered or deteriorated through prolonged use, it is necessary in the first place to decide what constitutes the main characteristic of a good lubricating oil.

It is not necessarily dependent on its specific gravity, though one should not expect too much from a mineral oil over 0.935 gravity, as the oils that are usually associated with this gravity generally contain a considerable proportion of unsaturated hydrocarbons and are therefore more predisposed to break up under the punishing conditions obtaining in a Diesel engine. Straight hydrocarbon oils ranging in specific gravity from 0.885 to 0.9 usually indicate an oil of more stable quality, less likely to decompose.

Neither is viscosity the only criterion of the lubricating qualities of an oil, although it is an important one, and in this connection it is interesting to note the trifling changes in viscosity in filtered oil from that which it had when new.

Alterations in flash point after continued use may be of concern to those in charge of inclosed engines, but probably reveal nothing beyond the percentage of leakage of fuel oil into the crank chamber and the degree of cracking that has taken place in the lubricating oil due to charring.

According to some chemical engineers the outstanding lubricating property of an oil, although closely allied to viscosity, is what for want of a better word may be called its "slipperiness." The investigations made by the propounders of the "germ" theory go to show that the degree of oiliness, or "slipperiness," in an oil is in turn dependent on its "capillarity," or readiness to spread and wet the surfaces of the metal parts. This capillary function appears greatly helped by the oil having a low surface or interfacial tension, and it would seem to be demonstrated that the presence of a small proportion of free fatty acids in the oil does lower the tension and thereby increases the capillarity.

Effect of Fatty Acids in Lubricants

The question of lubrication has interested engineers for many years, and in the past many tests on lubricating oils recovered from the crankcases of high-speed internal-combustion engines have been carried out. It has been found that there is always an increase in the fatty acids, due apparently to the oxidation of paraffin bodies. This oxidation process is being carried out in Germany on a commercial scale. Paraffin oil is simply subjected to the action of oxygen in the presence of catalyzers, fatty acids being produced. The higher paraffins are much easier to convert to fatty acids than the class of oil generally used for lubricating purposes. It was demonstrated in a paper recently read before the Society of Chemical Industry that a trace of fatty acids, say up to ½ per cent, in lubricating oil is quite favorable so far as lubrication is concerned, as it tends to lower the interfacial tension between the oil and the metal in contact with it. The removal of friction between rubbing surfaces is dependent upon there being at least a single layer of molecules between the surfaces. If a piece of fine-grained cast iron be taken and drops of a purely hydrocarbon lubricating oil and a fatty or animal oil of the same specific gravity placed on the surface, it will be found that the animal oil will run up the surface of the metal in an astonishing manner compared with the mineral oil. There are, however, many disadvantages attached to the presence of animal oil in quantity in lubricants for high-speed engine work. Difficulties in the case of a Diesel engine are perhaps not so great because the engine is running on a fuel of much the same specific gravity as the lubricating oil, but in the case of petrol engines the difficulty is considerable. A certain amount of fuel is almost certain to leak past the piston rings on the compression stroke and to find its way eventually to the crankcase. During the early days of the war, when petroleum was in great demand, drivers of taxicabs had been advised to run their engines on a mixture of petroleum and paraffin. The result had been an unprecedented rate of mortality in big-ends.

In the case of the hot-bulb engine the fuel employed suffers a certain degree of cracking. This cracking results in the formation of simpler and more volatile hydrocarbons, and it is possible that these might get past the rings to a slight extent, thus gradually reducing the viscosity of the lubricating oil in the crankcase. This effect could not take place in a Diesel to anything like the same degree. It is desirable, therefore, that experimental work should be continued in the direction of examining very closely lubricating oil which has been in continuous use in hot-bulb and other types of high-compression oil engines. The author's own experience goes to show that a lubricating oil as such suffers no deterioration by continued use, and that anything corresponding to deformation is impossible. Such changes as do occur are due to oxidation and to the introduction of foreign material brought in from the cylinder or elsewhere.

*Extract of paper read before the Diesel Engine Users Association.

The Federation's Work

L. W. Wallace, the executive secretary of the Federated American Engineering Societies, has issued a statement which gives a good idea of what the Federation is doing and plans to do.

He said that a plan has been worked out for rendering personal service to engineers visiting Washington, with the object of reducing the amount of effort required on their part in transacting their Washington business. Engineers are asked to notify the new Washington office, which is the national headquarters of the Federation, at 719 Fifteenth St., N. W. (National Savings and Trust Building), when they plan to visit the capital, so that arrangements may be made to care for them. There is space available at headquarters where visiting engineers may hold conferences and transact business. Mr. Wallace will be located there permanently in the near future.

Mr. Wallace reported good progress on the part of the committee on elimination of waste in industry. All the field work is to be completed by April 15, after which the results will be put into a final report dealing with the causes and amounts of the waste that exists in ten leading industries. This report is expected to be published some time in June. Splendid co-operation is reported from all the agencies approached in the investigation.

Mr. Wallace called attention to the fact that the opportunity of coming into the Federation as a charter member will expire on July 1. The Boston Society of Civil Engineers and the Engineering Society of Milwaukee have joined lately, he said, and it is expected that a number of other societies will join before July.

Good Progress in Skagit Development

Completion of the Newhalem Creek power plant by June 15 will put into operation the first unit of the Skagit power project, C. F. Uhden, engineer in charge, has announced. The plant will develop 3,000 hp. from water delivered through a 2,700-ft. tunnel and a 900-ft. steel pipe line from a dam three-fourths of a mile up the creek. Work on the rock tunnel has been rushed during the winter, and the railroad from Rockpoint to Newhalem is nearing completion, all of the rails being in place and the ballast work being almost completed.

While the Newhalem unit will begin generating power June 15, according to the plans, no electricity will be furnished to Seattle at first. The power will be used instead in the work on Gorge Creek, the next step in the Skagit development; after completion of this work the power will be delivered to Seattle.

New Publications

CAMS, ELEMENTARY AND ADVANCED. By Franklin DeR. Furman. Published by John Wiley & Sons, Inc., New York, and Chapman & Hall, London. 229 pages; 182 illustrations.

Although the book was written primarily as a textbook for students in mechanical engineering, it should prove useful to anyone having problems to meet in the design of apparatus in which cams are used. One especially valuable feature explains how to determine how small a given cam can be made without exceeding an angle of pressure that will permit of smooth running at a given speed. This and similar material is presented in such a way as to enable the designer to choose the type of cam best adapted to the particular work to be done.

FINDING AND STOPPING WASTE IN MODERN BOILER ROOMS. Published by the H. S. B. W. Cochrane Corp., Philadelphia, Pa., 1921. Cloth; 4¾ x 7 in.; 414 pages; illustrated. Price, $1.

This is the second edition, in which the book has been enlarged from 274 to 414 pages. The original text has been revised and new matter put in, some of which deals with higher steam pressures and the burning of wood and low-grade fuels. A Marks and Davis steam table has also been added. The book is described by the publishers as "a reference manual to aid the owner, manager and operator in securing and maintaining boiler-plant economy." It is written simply enough to be easily understood, but nevertheless covers very thoroughly the principles and the best methods of operation of all forms of boiler-room apparatus.

MODERN MARINE ENGINEERING. By Henry G. Eisen. Published by D. Van Nostrand Co., 8 Warren St., New York City, 1921. Cloth. 5x7¼ in.; 205 pages; 66 illustrations. Price, $3 net.

The preface of this volume states that while it is primarily intended as a text for schools and colleges, it has also been adapted to the needs of the practical man who desires to broaden his knowledge and to advance in his profession. The present volume, No. 1, is elementary in character and will meet the requirements of the man who knows nothing about marine matters better than it will those of the man who has had experience in handling marine apparatus. The book is divided into fourteen lessons, each accompanied by a set of questions.

THE TESTING OF MOTIVE-POWER ENGINES. By R. Royds, M. Sc. Published by Longmans, Green & Co., New York City. Cloth, 6 x 9 in.; 380 pages; 83 illustrations. Price, $7.50.

The treatise is intended for students of engineering who are in possession of an elementary knowledge of heat engines. The volume fully covers the methods of testing engines of all types. Worthy of especial mention are the chapters on the testing of internal-combustion engines. The rapid increase in popularity of these engines necessarily requires more attention given to problems of testing. Likewise the chapters devoted to the testing of refrigerating plants should be of interest to all refrigeration engineers. From the viewpoint of the American engineer it is unfortunate that many of the symbols used are not those in common usage in this country. Certainly, some steps should be taken by the engineering bodies to secure a uniformity in nomenclature in technical treatises.

CAM DESIGN AND MANUFACTURE. By F. B. Jacobs. Published by D. Van Nostrand Co., 8 Warren St., New York City, 1921. Cloth; 6x9 in.; 121 pages; 89 illustrations. Price, $2.

In the preface of this well-written, well-printed and well-indexed little volume the author states that he "has avoided using complicated mathematical formulas, as it is well known that very few men actually engaged in machine design and construction thoroughly understand them." He has accordingly treated the subject matter in a clear and concise way, the seven chapters being devoted respectively to "Machine-Cam Design," "Gas-Engine-Cam Design," "Cam Followers," "Master Cams," "Machine Work on Cams and Cam Cutters," "Cam Cutting" and "Cam Grinding." The book is thoroughly practical and proves the truth of the author's statement that "it is certainly possible to explain some of the methods that are in actual use for laying out and cutting cams."

ANALYSES OF IOWA COALS

The Bureau of Mines has collected, out of its analyses of coal in all parts of the country, coal statistics for the State of Iowa and has republished them in Technical Paper 269, a 28-page pamphlet that may be obtained at a nominal cost from the Superintendent of Documents, Government Printing Office, Washington, D. C.

Personals

J. H. Anderton has left Stone & Webster Corporation to join the firm of Thebo, Starr & Anderton, engineers and constructors, Sharon Bldg., San Francisco.

E. J. Tracy, who was formerly master machinist at the Conners Creek Plant of the Detroit Edison Co., is now chief engineer of the company's new service station.

N. K. Althouse, previously assistant engineer of the Braden Copper Co., has become associated with the Homestead Valve Manufacturing Co., New York City, as sales engineer.

W. D. Mann is now with the Pneumercator Company, New York. He was formerly combustion engineer in the engineering department of the Petroleum Heat and Power Co., Boston, Mass.

Dr. William Cawthorne Unwin, F. R. S., of London, has been awarded the Kelvin Gold Medal by a committee of the presidents of the principal representative British engineering institutions.

R. L. Ellis has been appointed manager of the Miami Beach Electric Co.'s new $250,000 plant, which furnishes Miami Beach, Fla., with its light and power. He was formerly with the Birmingham (Ala.) Railway, Light and Power Co.

Society Affairs

The Detroit Engineering Society will hold its 27th annual banquet April 29 in the Hotel Cadillac.

The Engineers' Club of Philadelphia is to give a dinner to Herbert Hoover April 16 in the Bellevue-Stratford Hotel.

The Society of Automotive Engineers will meet April 19 to hear a talk by H. C. Mock on "Carburetor Development," at the University Club, Buffalo.

The American Society of Heating and Ventilating Engineers has announced that its next semi-annual meeting is to be held June 14-16 in Cleveland.

The Cincinnati Section of the A. S. M. E. will be addressed April 21 on "Rehabilitation of Men," by John T. Faig, president of the Ohio Mechanics Institute.

The Engineering Society of Buffalo is to hold its annual meeting for the election of officers at the University Club April 12. "X-Rays and Crystal Structures" and "Vocational Education" will be discussed.

Metropolitan Section, A. S. M. E., will hold a joint meeting with the American Institute of Electrical Engineers on April 22. Prof. Comfort A. Adams will be in charge of the meeting and the subject will be "Engineering Education."

Atlanta, Birmingham and New Orleans Sections, A. S. M. E., are to hold a joint regional meeting at Mobile, Ala., on April 22, which the A. S. M. E. council will attend. The meeting will last all day and will include a trip to the Chickasaw shipyard and power plant.

The National Association of Stationary Engineers has completed final arrangements to hold its annual convention in Evansville,

Ind., Sept. 12-17. It was found impossible to secure the right dates at Springfield, Mass., which was previously decided upon and announced as the convention city.

The Western Geographic Section of the Pennsylvania Electric Association will hold a symposium on electric service at the William Penn Hotel, Pittsburgh, on April 15. "The Ideal Power Customer for the Central Station" will be discussed in the morning from both the commercial and technical standpoints, and in the afternoon "The Ideal Central-Station Power Service" will be treated from the viewpoints of the steel plant and the coal mine.

The American Institute of Electrical Engineers and the Association of Iron and Steel Electrical Engineers will hold a joint meeting in Pittsburgh, April 18. The subject of the meeting will be the new Colfax Station of the Duquesne Light Co. In the morning a trip will be made through the plant, and in the afternoon a meeting will be held at Carnegie Hall, when papers on the plant will be presented by T. L. Galusha and C. E. W. Clarke. In the evening, at the William Penn Hotel, B. G. Lamme will read a paper on "The Problem of Conversion from Sixty Cycles to Twenty-five Cycles," and C. M. Petty will speak on "Some Results in the Changing of Sixty Cycles to Twenty-five Cycles."

Miscellaneous News

The Federal Power Commission has recently issued order No. 9, consisting of the new rules and regulations of the commission, effective Feb. 28, 1921. Those who have business to transact with the commission, such as making application for permits or licenses, should secure a copy of the book by writing to the Federal Power Commission, Washington, D. C.

State Water Power Control and development is proposed in a constitutional amendment recently introduced into the Maine Legislature by Governor Baxter. The object of the bill is to prevent the Federal Government from taking over control of water power in the State of Maine. It contemplates the taxation of all water powers and whatever fees and energy result from their use.

The Licensing of Engineering Corporations was absolutely prohibited by a bill recently pending in the New York State Legislature. It was amended, however, to premit granting of licenses to engineering corporations on condition that the individuals who actually carry on the engineering practice of the corporation must themselves hold licenses. The bill requires licenses of all engineers practicing in New York State. The amended bill has received the indorsement of the Merchant's Association of New York, which is urging its adoption upon the Legislature.

Business Items

The Coon-DeVisser Co., contracting sales engineers, have moved their offices to 1772 West Lafayette Boulevard, Detroit, Mich.

Charles Lennig Co., Bridesburg, Pa., of which A. L. Harbottle is chief engineer, is making plans to re-equip its power plant.

The Homestead Valve Manufacturing Co., Inc., Homestead, Pa., has appointed E. E. Jones in charge of its New York City office at 242 Lafayette St.

Crocker-Wheeler Co., Ampere, N. J., has moved its Boston office to larger quarters at 171 High St. (Cornhill Square). L. S. Howland continues as district manager.

The American Engineering Co., of Philadelphia, maker of the Taylor Stoker, has established a mid-Western service station at 1772 West Lafayette Boulevard, Detroit, Mich.

The Steam Motors Co., Inc., of Springfield, Mass., is now represented in the Philadelphia territory at 723-25 North 24th St., Philadelphia, Pa., under the management of Anderson MacPhee.

The Ames Iron Works, Oswego, N. Y., is to establish early in April direct branch sales and service offices at 1033-1035 Commercial Trust Building, Philadelphia, Pa., under direction of E. A. Hahl and H. Schluter as district managers.

The Standard Supply and Equipment Co., 71 Murray St., New York City, has, by recent arrangement, taken over the New York agency for "The Reeves" variable speed transmission and "The Reeves" wood split pulley. This agency was formerly vested in Patterson, Gottfried & Hunter, Inc.

The Conveyors Corporation of America, Chicago, has announced the appointment of Robert B. M. Wilson as sales engineer of the Chicago district. E. M. Wolfe will be associated with him as an assistant, and headquarters will be maintained in the corporation's main office at 326 West Madison St.

Trade Catalogs

The Wheeler Condenser and Engineering Co., Carteret, N. J., is sending out its new Bulletin No. 114, describing the Lillie Evaporator, used for the production of distilled boiler-feed water.

The W. E. Ellis Co., Haverhill, Mass., is distributing a new 6x9-in. 16-page catalog on the Negus-Tiffany coal agitator. The purpose of the agitator is to prevent the blockading or choking of coal in the hoppers of multiple-retort underfeed stokers.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

Coal	Market Quoted	Mar. 29, 1921	April 5 1921
Pocahontas,	Columbus	$3.25	$3.50
Clearfield,	Boston	2.50	2.00@2.85
Somerset,	Boston	3.00	2.35@3.75
Pittsburgh,	Pittsburgh	2.25	2.00@2.50
Kanawha,	Columbus	2.35	2.35
Hocking,	Columbus	2.25	2.25
Pittsburgh No. 8	Cleveland	2.25	2.00@2.35
Franklin, Ill.,	Chicago	3.40	3.25@3.50
Central, Ill.,	Chicago	2.25	2.00@2.50
Ind. 4th vein,	Chicago	2.65	2.25@3.00
Standard,	St. Louis	1.85	1.90@2.00
West Ky.,	Louisville	2.50	2.00@2.75
Big Seam,	Birmingham	2.85	2.70@3.00
S. E. Ky.,	Louisville	2.65	2.65@2.75

DIESEL FUEL OIL

New York—On March 30, Port Arthur light oil, 23@25 deg. Baumé; 30@35 deg., 7c. per gal. f.o.b. Bayonne, N. J.

Chicago—24@28 deg. Baumé, $1.10@$1.20 per bbl.; 32@34 deg., 3¾@4¼c. per gal.

Cincinnati—In 8,000-gal. tank cars: 26@28 deg., 7c. per gal.

St. Louis—April 2, prices f.o.b. cars, tank lots: 24@26 deg. Baumé, 80c. per bbl. 32@34 deg., 3c., 16@20 deg., 3¾c. per gal.

Baltimore—On April 4, f.o.b. Baltimore in tank-car lots: 24+ deg. Baumé, 6¼c.; 26@28 deg., 6½c.; 30@34 deg., 7¾c.; 14+ deg., $1.95 per bbl.; 16@20 deg., $1.85 per bbl.

Pittsburgh—On April 4, f.o.b. refinery; Pennsylvania, 36@40 deg., 5c. per gal.; Oklahoma, 22@24 deg., 60@70c. per bbl., 24-26 deg., 75c., 26@30 deg., 80@90c.; gas oil, 32@34 deg., 2¼c. per gal., 36@38 deg., 3¼c., 38@40 deg., 4c.

Philadelphia—On April 4: 26@28 deg. Baumé, Oklahoma, 85c. per bbl.; 30@34 deg., Oklahoma (group 3) 3c. per gal.; 16@20 deg., Seaboard, 5c. per gal.

New Construction

PROPOSED WORK

Me., South Portland—(Portland P. O.) Monks & Johnson, Archts. and Engrs., 99 Chauncey St., Boston, Mass., will receive bids about May 1 for a 6 story, 60 x 120 ft. canning factory and wharf on Front St., for the William Underwood Co., 52 Fulton St., Boston, Mass. About $250,000.

Mass., Natick—The School Comn. plans to build a 2 story school building and assembly hall. About $275,000. Architect not yet selected.

N. Y., Copenhagen—The Deer River Power Co. plans to install additional 1000 hp. generator and turbine wheel for same. Address V. C. Wood.

N. Y., Flushing, L. I.—Georgian Terrace Apartment Hotel, 275 State St., is having plans prepared for a 9 story, 320 x 360 ft. hotel, including a steam heating system, on Bway. About $1,000,000. Renwick, Aspinwall & Tucker, 8 West 40th St., New York City, Archts. and Engrs.

N. Y., Geneva—The Geneva Preserving Co., 55 North St., plans to build a 3 story, 190 x 200 ft. cold storage building. Cost between $60,000 and $70,000. Address E. S. Thorne.

Conn., New London—The Bd. Educ. received bids for installing heating, plumbing and mechanical equipment in the proposed 2 story, 88 x 310 ft. high school on Williams and Mercer Sts., from M. A. Dame & Son Co., Lynn, Mass., $94,600. Noted March 22.

N. Y., Green Island—(Troy, P. O.) Henry Ford & Sons, Boulevard and Woodward St., Detroit, Mich., are having plans prepared for a 65 x 300 ft. hydraulic station here, to have a 6000 k.w., a.c., 3 phase, 60 cycle capacity. About $2,000,000. Stone & Webster, 147 Milk St., Boston, Engrs.

N. Y., New York (Manhattan Boro)—The Bd. of Purchase, Municipal Bldg., will receive bids until April 15 for furnishing and delivering boiler and condenser tubes to the Departments of Plant and Structure and Water Supply, Gas and Electrcity.

N. Y., New York (Manhattan Boro)—The Fire Dept. received bids for furnishing all labor and materials necessary for furnishing, delivering and installing complete steam turbine engines on the fireboats "James Duane" and "Thomas Willett," from the Kerr Turbine Co., 30 Church St., $29,500; Tebo Yacht Basin Co., ft. of 24th St., Brooklyn, $31,500; Natl. Dry Dock & Repair Co., 78 Broad St., $39,588.

N. Y., New York (Manhattan Boro)—S. Friedenberg, c/o Springsteen & Goldhammer, Archts. and Engrs., 32 Union Sq., plans to build a 1 story, 100 x 170 ft. theatre, including a steam heating system, on Burnside and Creston Aves. About $350,000.

N. Y., New York (Manhattan Boro)—The Pub. Sewerage Comn., 49 Lafayette St., will soon award the contract for furnishing and delivering pumps. About $1,000.

N. Y., Rochester—The Burger Bros., 39 North Water St., is in the market for all kinds of electric motors and appliances.

N. Y., Sheepshead Bay (Brooklyn Boro)—The Sands Realty Co., c/o Sellig & Finkelstein, Archts. and Engrs., 44 Court St., Brooklyn, will build a 4 story, 65 x 135 ft. apartment house including a steam heating system on Sheepshead Bay Rd., here. About $250,000. Work will be done by day labor.

N. Y., Yonkers—The Phillipsburgh Constr. Co., 15 North Bway., is in the market for pumps, etc.

N. J., Absecon—The City of Atlantic City, City Hall, Atlantic City, is receiving bids for furnishing and installing superheaters and jet ash conveyors for two 300 hp. Heine boilers at the pumping station here. L. Van Gilder, Engr.

N. J., Asyia (Grenlock P. O.)—The Bd. of Freeholders, Camden, will soon award the contract for a 49 x 49 almshouse and a 30 x 30 ft. infirmary. Bakery, kitchen, ice refrigerating equipment, 1 hp. motor, compressor, 12 hp. steam engine, condensor, steam pump, circulating brine pump, etc., will be installed in same. T. Stephen, 304 Masonic Temple, Camden, Archt.

N. J., Camden—The Pinewald Beach Co., c/o H. N. Moffett, Archt., 30 North 3rd St., is having plans prepared for a 3 story hotel to include a steam heating system and probably a motor and generator to develop electricity. About $75,000.

N. J., Trenton—The Bd. Educ. plans to build a 2 and 3 story school including a steam heating system, etc., here. About $300,000. W. A. Poland, Archt.

N. J., Trenton—St. Francis Hospital, Chambers and Hamilton Aves., plans to build a 2 story hospital including a steam heating system, etc. About $500,000. Architect not yet selected.

N. J., Wildwood Crest—Pittsburgh Capitalists, c/o H. K. Reed, 34 South 17th St., Philadelphia Pa. plans to build a 4 story hotel here. About $500,000. Marshall & Ford, 721 North Michigan Ave., Chicago, Ill., Archts.

Pa., Pittsburgh—The St. Philomenas Parish will soon award the contract for a 2 story, 100 x 154 ft. school and 37 x 54 ft. convent on Foward and Beechwood Blvd. Cost between $400,000 and $500,000. J. T. Comes, Renshaw Bldg., Archt.

Md., Baltimore—The city plans to build a hospital. About $650,000. E. H. Glidden, American Bldg., Archt.

Md., Baltimore—The Fifth Dist. Federal Reserve Bank, South and Redwood Sts., plans to build a federal reserve bank on Lexington and Culvert Sts. About $1,000,000. Parker Thomas & Rice, Union Trust Bldg., Archts.

Md., Baltimore—The Grand Lodge Masons is having preliminary plans prepared for Masonic temple on St. Paul St. About $1,000,000. C. N. Friz, Lexington Bldg., Archt.

Md., Baltimore—Gwynn's Falls Paper Co., c/o J. H. Wallace & Co., Archts. and Engrs., 5 Beekman St., New York City, is having plans prepared for a paper mill at Gwynn's Falls here. About $500,000.

Md., Lock Raven—The city of Baltimore received low bids for raising and adding to the present dam, from the Whiting Turner Constr. Co., Stuart Bldg., Baltimore, $478,166. James Hillhouse Fuertes and Nicholas S. Hill, consult. engrs., will decide whether or not a balancing reservoir or a pumping station is the better plan for carrying the water from here to Baltimore.

D. C., Bellevue—The Bureau of Yards & Docks, Navy Dept., Wash., D. C., plans to install a reciprocating air compressor here.

Va., Buchanan—The Buchanan Light & Water Co. plans to build a 38 x 75 ft. light and water steam power plant including a flight conveyor type coal hoist, 1200 hp. boiler, etc. About $85,000. L. Hudson, Wabash Bldg., Pittsburgh, Pa., Engr.

Va., Relee (South Washington P. O.)—The N. Auth Provision Co., 623 D St., S. W., Washington, will receive bids for a 3 story, 93 x 166 ft. abattoir building including a refrigeration system at Columbia Pike. About $300,000. Julius Wenig, 721 10th St., N. W., Washington, Archt.

N. C., Asheville—The French Broad River Development Co. plans to build a dam 100 to 125 ft. high on the French Broad River above here to develop 8,000 to 9,000 hp., forming lake 30 mi. long and 3 mi. wide. Cost between $7,000,000 and $10,000,000. W. S. Wetmur, Hendersonville, Pres. J. Hyde Pratt, Chapel Hill, Engr.

Fla., Arcadia—The City Council appointed a committee, D. L. Smith, Chn., to investigate necessary changes with a view to installing new pumping equipment, air lift and reservoir. Cost between $5,000 and $20,000.

Fla., St. Petersburg—The city plans to construct a building and install new electrically driven pumping equipment, and 2 wells, etc. About $118,000.

Ala., Rockford—E. E. Brown is in the market for air pumps and gas engines for mica mining.

Tenn., Johnson City—The Chamber of Commerce is having plans prepared for a 10 story hotel including a steam heating system. About $450,000. W. L. Stoddart, 9 East 40th St., New York City, N. Y., Archt. and Engr.

Ky., Dawson Springs—J. A. Wetmore, Supervising Archt., Treasury Dept., Wash., D. C., received bids for a power plant here, from the Murch Bros. Constr. Co., 1855 Railroad Exch. Bldg., St. Louis, Mo., $42,000; Dawson Springs Constr. Co., $42,645; W. McDonald Constr. Co., Odd Fellows Bldg., St. Louis, Mo., $45,832.

Ky., Falmouth—The City Water Wks. is having plans prepared for a power plant and plans to install a 500,000 gal. pump (new) and remodel old power plant, etc. About $30,000. Glazier & Morlidge, 20 Miller Bldg., Cincinnati, O., Engrs.

O., Canton—The Continental Clay Co., Zinninger Bldg., will receive bids until May 1 for a sewer pipe factory. Estimated cost including equipment, $350,000. Noted April 7.

O., Cleveland—The Telling Belle Vernon Co., 3825 Cedar Ave., will receive bids about April 20 for a 40 x 75 ft. power plant, and will soon award the contract for furnishing equipment for same. About $50,000. A. C. Bishop & Co., Guardian Bldg., Engr.

O., Cleveland—The Woodland Market Co., c/o G. Paul, Fidelity Mortgage Bldg., will soon award the contract for a 2 story, 198 x 400 ft. market house and commercial building, including a steam heating and refrigerator system on East 55th St. and Woodland Ave. About $500,000. J. F. Steffens, Archt.

O., Dayton—The Dayton Savings & Trust Co., 25 North Main St., plans to build an 11 story, 25 x 190 ft. bank and office building on North Main St. About $500,000. Architect not yet selected.

O., Youngstown—C. H. Mills, c/o Eugene DeRosa, Archt. and Engr., 110 West 40th St., New York City, plans to build a theatre and office building including a steam heating system on Market Court. About $1,500,000.

Ind., Kendallville—The Bd. of Pub. Wks. will receive bids until April 14 for a 1 story, 50 x 65 ft. waterworks and electric light building. About $46,950. Three 300 hp. water tube boilers, 1 feed water heater and 2 boiler feed pumps will be installed in same. Froehlich & Emery Eng. Co., 412 Second Natl. Bank Bldg., Engrs.

Ind., Rockville—C. E. Kelly, Trustee, is having plans prepared for a 2 story tuberculosis sanatorium including children's building and nurses' quarters. About $250,000. Shourds-Stoner Co., 510 Tribune Bldg., Terre Haute, Archts. and Engrs.

Mich., Detroit—The Bd. Educ., 1354 Bway., will soon award the contract for a 7 story, 155 x 200 ft. school and a 2 story, 50 x 200 ft. gas engine laboratory on Second and High Sts. Separate contract for installing a heating system will be let. Malcolmson, Higginbothal & Palmer, 405 Moffat Bldg., Archts.

Ill., Chicago—A. M. Castle & Co., 715 North Morgan St., will soon award the contract for a 1 and 2 story, 210 x 230 ft. office and warehouse including a steam heating system on Blackhawk St. along the Chicago River. About $300,000. R. G. Schmidt & Co., 154 West Randolph St., Archt.

Ill., Chicago—The Chicago Lutheran Hospital Assn., 155 North Clark St., plans to build a 5 story hospital including a steam heating system. About $400,000. Worthmaure & Steinbach, Archts.

Ill., Chicago—The Swigart Paper Co., 653 South Wells St., plans to build a 10 story, 100 x 100 ft. paper warehouse including a steam heating system at 715 South Wells St. About $500,000.

Ill., Joliet—D. H. Burnham & Co., Archt., 209 South LaSalle St., Chicago, will receive bids until April 15 for a 3 story, 200 x 225 ft. addition to the high school including a steam heating system for the Bd. Educ. About $330,000.

Wis., Green Bay—The Deaconess Hospital, 742 South Webster St., plans to build a nurses' home, hospital addition and central heating plant. About $260,000. P. T. Benton, Archt.

Wis., Jones Island (Milwaukee P. O.)—The City Sewerage Comn. will receive bids until April 22 for 4 water tube boilers, mechanical stokers, superheaters, etc. T. C. Hatton, City Hall, Engr.

Wis., Milwaukee—The city is having preliminary plans prepared for a pumping staton to include 4 boilers, 3 pumps, etc., along the bank of the Milwaukee River here. About $1,500,000. C. A. Cahill, 217 West Water St., Consult. Engr. G. F. Stol, City Hall, Engr.

Wis., Milwaukee — A. C. Eschweiler, Archt., Goldsmith Bldg., plans to build a 4 story apartment house on Prospect Ave. About $500,000. Owner's name withheld.

Wis., Milwaukee—Milwaukee Co. will receive bids until April 14 for a lighting system for highways, etc. About $25,000.

Wis., Milwaukee—Roseman & Wierdma, Archts., 424 Jefferson St., are having plans prepared for a 6 story, 90 x 182 ft. apartment house on Grand Ave. About $350,000. Owner's name withheld.

Ia., Dubuque—The Bd. Educ. will receive bids unti April 20 for a 3 story high school including a steam heating system. About $550,000. J. W. Royer, Urbana, Ill., Archt.

Minn., Minneapolis—The Elks Lodge, Elks Bldg., 2nd Ave., South and 7th St., is having plans prepared for a 15 story clubhouse including a steam heating system on 4th Ave. South and 7th St. About $1,200,000. W. H. Ritchie, Pres.

Kan., Topeka—The city received bids for the installation of centrifugal pumps in connection with the proposed water purification and supply plant from the American Well Wks. Co., 319 Reliance Bldg., $3,398; Thermal Efficiency Co., 1210 Scarritt Bldg., $2,350; Beeson Machine Co., $2,845. Noted Sept. 28.

N. D., Minot—The Northern States Power Co., 76 West 3rd St., St. Paul, Minn., plans to improve its plant. About $110,000. J. F. McGuire, Local Mgr.

Mo., St. Louis—The Scottish Rite Cathedral Assn. is having plans prepared for a 2 story temple including a steam heating system on Grand and Lindell Sts. About $1,000,000. A. W. White, LaSalle Bldg., Secy. W. B. Ittner, Bd. Educ. Bldg., Archt.

Ark., Springdale—The Bd. of Comrs. of the Waterworks Imp. Dist. No. 1 will receive bids until April 15 for the installation of motor-driven deep well pumps, etc. About $5,000. F. L. Wilcox, Chemical Bldg., St. Louis, Mo., Engr.

Tex., Halletsville—The city will receive bids until April 14 for improvements to the electric light plant and installation of machinery including one 120 hp. steam engine direct connected to one alternating current generator 90 k.v.a., 2,300 volt, 3 phase, 60 cycle with exciter, etc.; one horizontal return tubular boiler, 150 m.p. for 150 lb. steam, one 150 hp. open type feed water heater, 2 simplex boiler feed pumps for this boiler. Alternate bids will be received for one 200 hp. direct connected to one alternating current generator, 150 k.v.a., 2,300 volts, 3 phase, 60 cycle with exciter, boiler, heater, pumps, etc.

Cal., Burbank—The city will receive bids until April 19 for equipment including three 200 k.v.a., 16,500 volt H.T. single phase, 50 cycle outdoor transformers; one 200 volt, 3 operating motor; one 40 k.v.a. induction feeder regulator; one primary and one secondary relay voltage compensator, etc.

Cal., Los Angeles—The Fifth Street Bldg. Co., 611 Trust & Savings Bldg., plans to build a 12 story store and office building on 5th St. and Bway. About $1,500,000. A. C. Martin, 430 Higgins Bldg., Archt.

Cal., Los Angeles—G. L. Molchan & Associates, 319 Baker-Detwiler Bldg., are having plans prepared for a 12 story hotel on 8th St. and Welshire Blvd. About $3,000,000. A. E. Curlett, 518 Merchants Bank Bldg., Archt.

Ont., London—The Utilities Bd. plans to install an electrical smelting plant and is in the market for equipment for same. About $10,000. E. V. Buchanan, City Hall, Engr.

Ont., Portland—T. A. Kerr, clerk of Portland Twp. will receive bids for a 17-20 hp. steam portable engine to drive rock crusher.

CONTRACTS AWARDED

Conn., Hartford—The Steger Vedder Co., 885 Main St. has awarded the contract for a 5 story addition to its department store building on Main St., to the Cauldwell Wingate Co., 381 4th Ave., New York City. About $500,000.

Conn., Middletown—The Middlesex Hospital Bd. of Trustees, has awarded the contract for the installation of a heating and plumbing system in the proposed 4 story, 40 x 100 ft. hospital addition on Crescent St., to the Bacon Bros., 345 Main St. Noted March 29.

N. Y., New York (Brooklyn Boro)—Cary Harmon & Co. Inc., 144 Montague St., has awarded the contract for a 6 story apartment house including a steam heating system at 184 Columbia Heights, to F. F. French & Co., 299 Madison Ave., New York City. About $250,000.

N. Y., New York (Brooklyn Boro)—The Sherman Johnson Co., c/o Seelig & Finkelstein, Archts. and Engrs., 44 Court St., will build a 4 story, 110 x 115 ft. apartment house including a steam heating system on Regent Pl. and East 21st St. About $250,000. Work will be done by day labor.

N. Y., New York (Manhattan Boro)—The Co-operative Ownership, c/o Bottomley & Hess, Archts. and Engrs., 597 5th Ave., has awarded the contract for a 12 story 75 x 100 ft. apartment house including a steam heating system on Park Ave. and 63rd St., to the McIntosh Constr. Co. About $850,000.

N. Y., New York (Manhattan Boro)—Haring & Blumenthal, 1600 Eway, will build a theatre on Brown Pl. and Brook Ave., between 137th and 138th Sts. About $400,000. Work will be done by day labor.

Pa., Bakerstown—The Pittsburgh Cut Flower Co., 7th Ave., Pittsburgh, has awarded the contract for a 1 story, 42 x 75 ft. boiler house here, to G. Schenk Co., Butler, Pa. Cost between $40,000 and $50,000. Noted March 29.

D. C., Washington—The Dist. Comrs. have awarded the contract for the installation of a heating and ventilatng system in the Burrville School, to the Standard Eng. Co., 2129 I St., N. W. About $25,390.

Ill., Rockford—The city has awarded the contract for a pumping station and boiler room and for the installation of a well, air lift and complete pumping equipment including a 500,000 gal. reservoir, 2,250 cu. ft. air compressor, 15,000,000 gal. light duty steam driven pump, to Ross P. Beckstrom & Co., Indiana Ave. About $90,000.

Ont., London—The Utilities Bd. will build a 2 story, 40 x 80 ft. electric station including electrical equipment. About $60,000. Work will be done by day labor.